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

Numerical 1: Find voltage across 35 Ω resistance. Solve analytically using mesh analysis

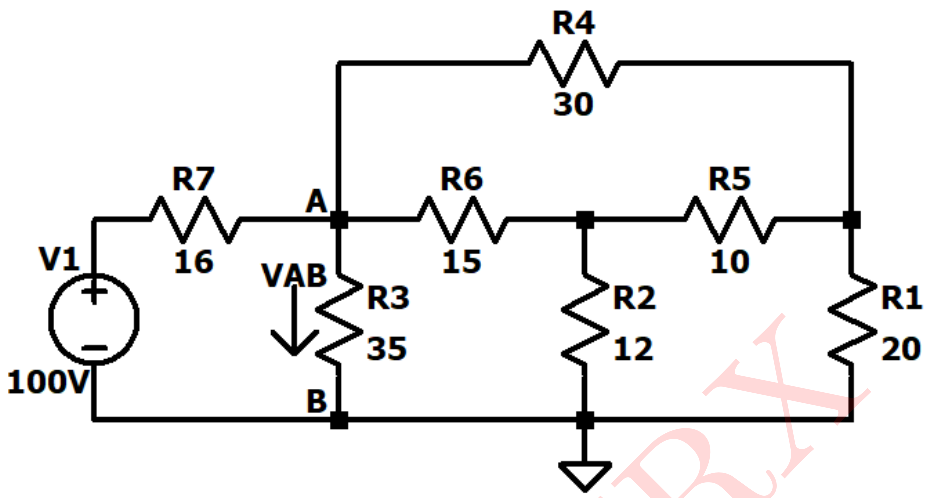


Figure 1: Circuit 1

Solution:

Applying KVL to mesh 1:
$100 - (16 + 35)I_1 + 35I_2 = 0$
$100 - 51I_1 + 35I_2 = 0$
$51I_1 - 35I_2 = 100$ ....(1)

Applying KVL to mesh 2:
$35I_1 - (35 + 15 + 12)I_2 + 12I_3 + 15I_4 = 0$
$35I_1 - 62I_2 + 12I_3 + 15I_4 = 0$ ....(2)

Applying KVL to mesh 3:
$12I_2 - (12 + 20 + 10)I_3 + 10I_4 = 0$
$12I_2 - 42I_3 + 10I_4 = 0$ ....(3)

Applying KVL to mesh 4:
$15I_2 + 10I_3 - (15 + 10 + 30)I_4 = 0$
$15I_2 + 10I_3 - 55I_4 = 0$ ....(4)

Solving equation (1), (2), (3) and (4) simultaneously, we get

$I_1 = 3.6138\text{A}$
$I_2 = 2.4086\text{A}$
$I_3 = 0.8828\text{A}$
$I_4 = 0.8174\text{A}$
$V_{AB} = (3.6138 - 2.4086) \times 35$
$V_{AB} = 42.182\text{V}$

SIMULATED RESULTS:

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

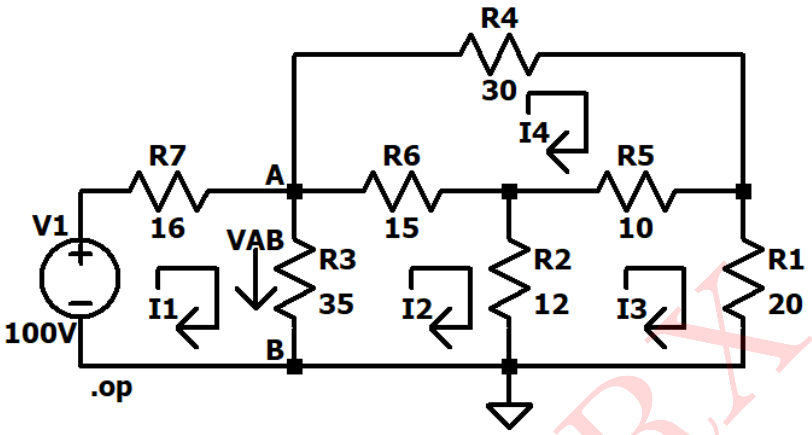
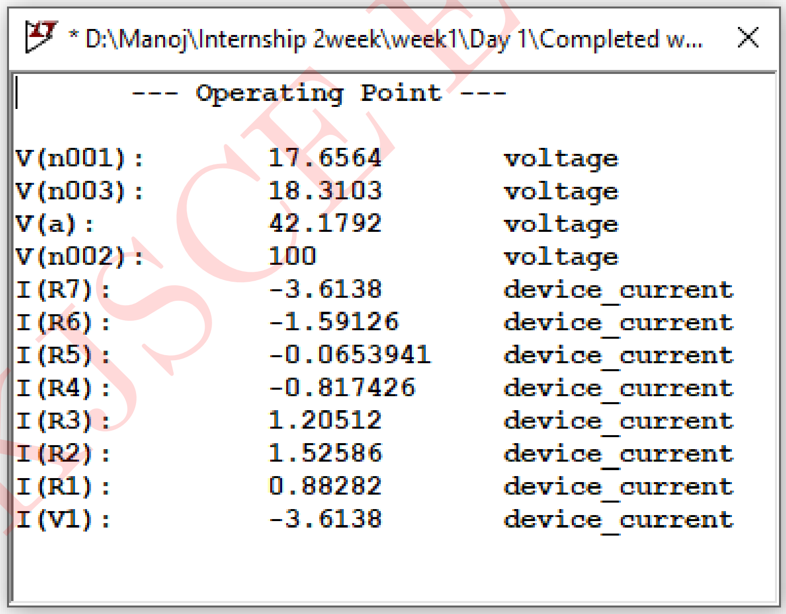


Figure 2: Circuit Schematic



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--- Operating Point ---

V(n001):	17.6564	voltage
V(n003):	18.3103	voltage
V(a):	42.1792	voltage
V(n002):	100	voltage
I(R7):	-3.6138	device_current
I(R6):	-1.59126	device_current
I(R5):	-0.0653941	device_current
I(R4):	-0.817426	device_current
I(R3):	1.20512	device_current
I(R2):	1.52586	device_current
I(R1):	0.88282	device_current
I(V1):	-3.6138	device_current

Figure 3: Simulated Results

Comparison of Theoretical and Simulated Values:-

Parameters	**Theoretical Values**	**Simulated Values**
V_{AB}	42.182V	42.1792V

Table 1: Numerical 1

Numerical 2: Find equivalent resistance at terminals

a) a − b

b) c − d

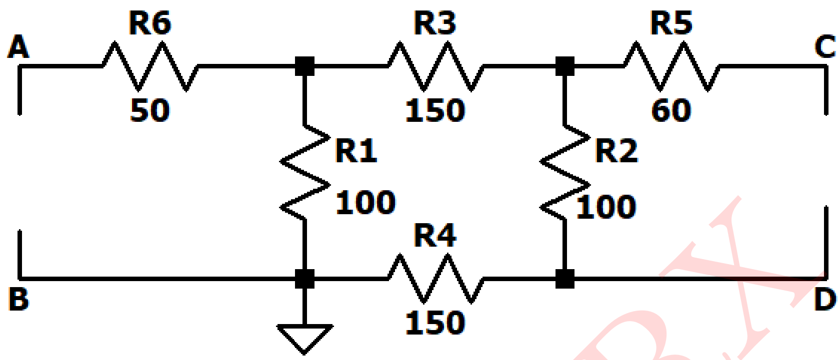


Figure 4: Circuit 2

Solution:

a) a − b

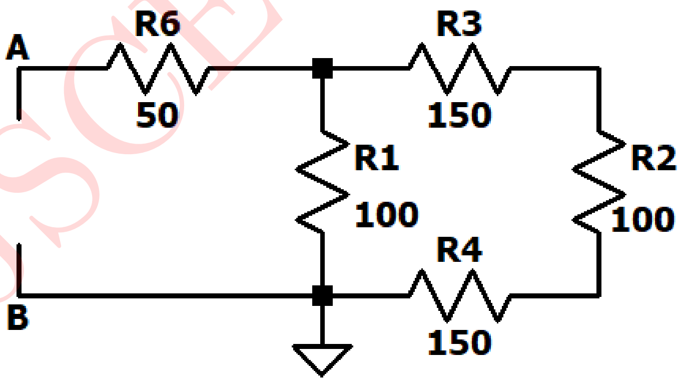


Figure 5: Equivalent circuit for a − b section

$$\begin{aligned} R_{AB} &= 50 + \frac{100 \times 400}{100 + 400} \\ &= 50 + \frac{4 \times 10^4}{500} \\ &= 50 + \frac{400}{5} \\ &= 50 + 80 \end{aligned}$$

$\therefore R_{AB} = 130\ \Omega$

b) c − d

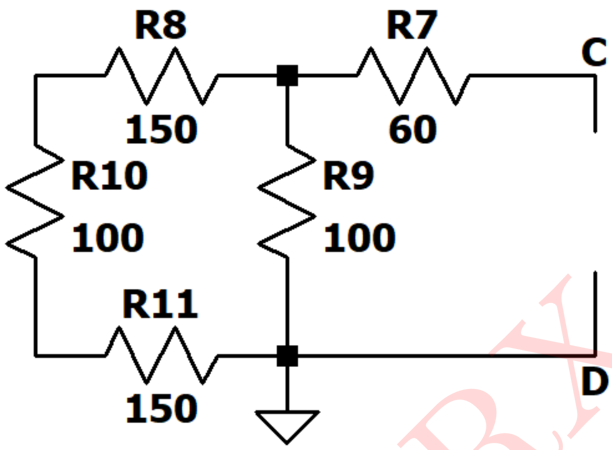


Figure 6: Equivalent circuit for c − d section

$$
\begin{aligned}
R_{CD} &= 60 + \frac{100 \times 400}{100 + 400} \\
&= 60 + \frac{4 \times 10^4}{500} \\
&= 60 + \frac{400}{5} \\
&= 60 + 80 \\
\therefore R_{CD} &= 140\ \Omega
\end{aligned}
$$

SIMULATED RESULTS:

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

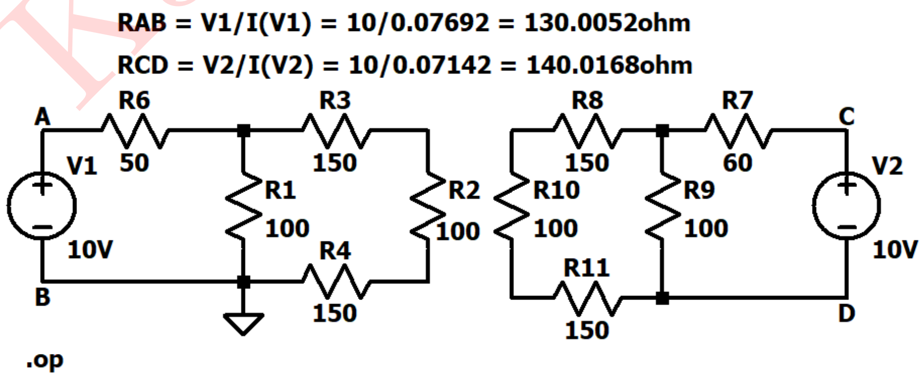


Figure 7: Circuit Schematic

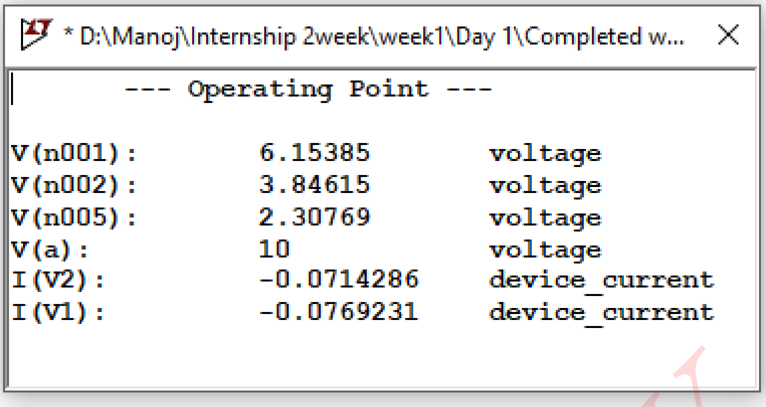


Figure 8: Simulated Results

Comparison of Theoretical and Simulated Values:-

Parameters	**Theoretical Values**	**Simulated Values**
R_{AB}	130 Ω	130.0052 Ω
R_{CD}	140 Ω	140.0168 Ω

Table 2: Numerical 2

Numerical 3: Find current in 2Ω resistor by using Thevenin's Theorem.

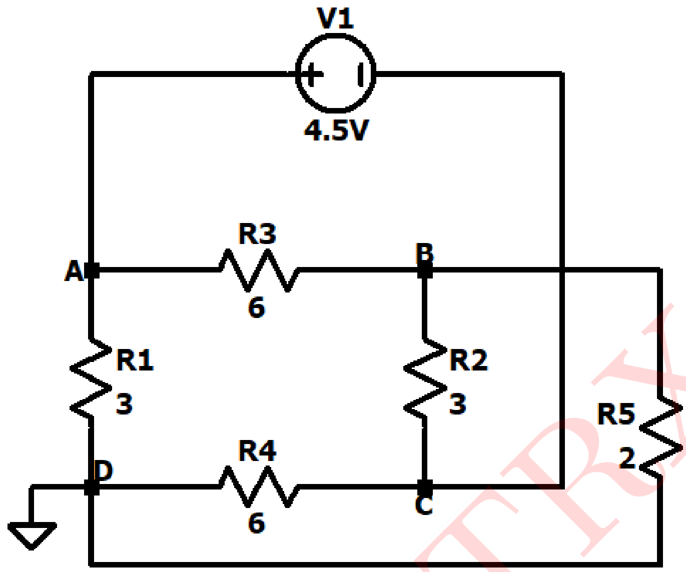


Figure 9: Circuit 3

Solution:

1) Calculation of V_{TH} :-

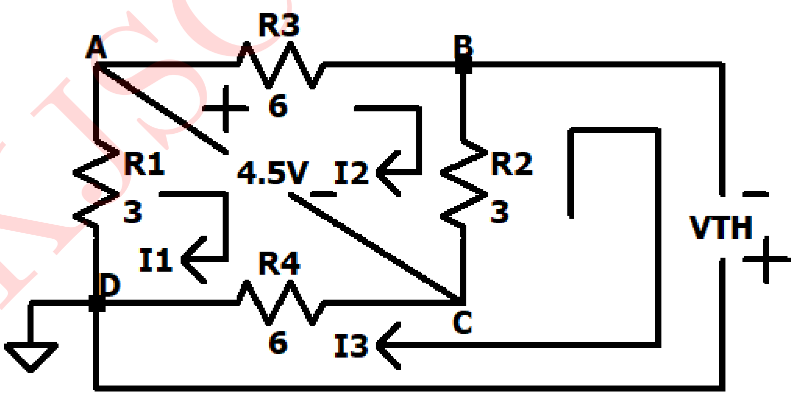


Figure 10: Circuit for V_{TH}

Applying KVL to mesh 1:

$-6I_1\ -3I_1\ -4.5 = 0$

$-9I_1 = 4.5$

$I_1 = \dfrac{-4.5}{9}$

$I_1 = -0.5\text{A}$ ....(1)

Applying KVL to mesh 2:

$-6I_2 \; -3I_2 + 4.5 = 0$

$9I_2 = 4.5$

$I_2 = \dfrac{4.5}{9}$

$I_2 = 0.5\text{A}$ ....(2)

Applying KVL to mesh 3:

$V_{TH} = 6I_1 + 3I_2$

$= 6 \times (-0.5) + 3 \times 0.5$ ....From (1) and (2)

$= -1.5\text{V}$

2) Calculation of R_{TH} :-

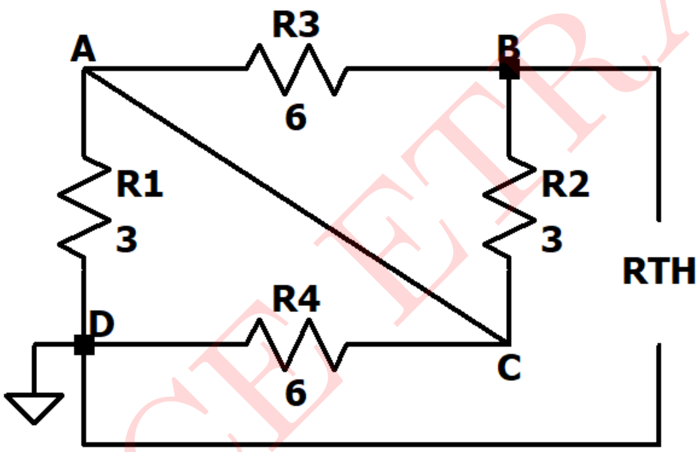


Figure 11: Circuit for R_{TH}

From the above circuit 3Ω and 6Ω are parallel with each other in loop ADC and ABC

$\therefore R_{TH} = \dfrac{3 \times 6}{3+6} + \dfrac{3 \times 6}{3+6}$

$= \dfrac{6}{3} + \dfrac{6}{3}$

$= 2 + 2$

$\therefore R_{TH} = 4\Omega$

3) Calculation of load current :-

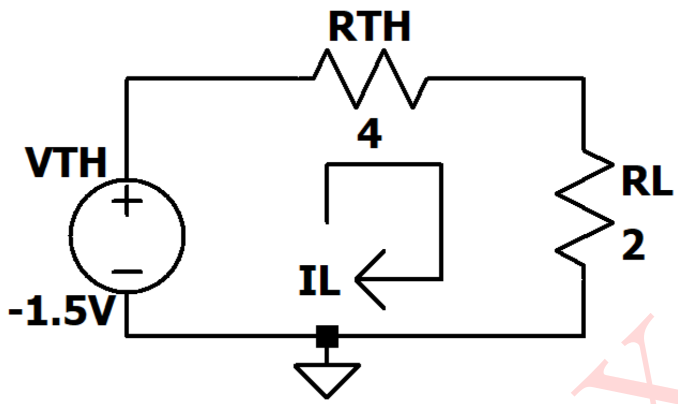


Figure 12: Thevenin's equivalent circuit

Applying KVL to mesh 1:

$-6I_L - 1.5 = 0$

$\therefore I_L = -0.25\text{A}$

SIMULATED RESULTS:

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

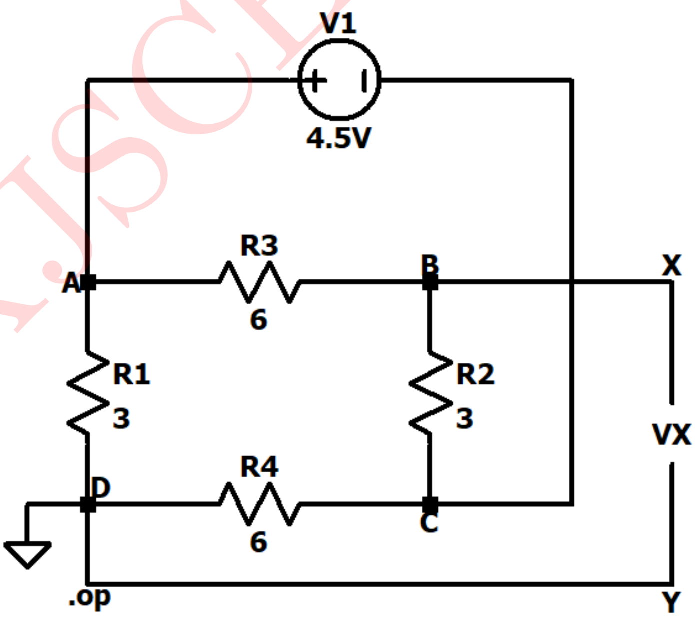
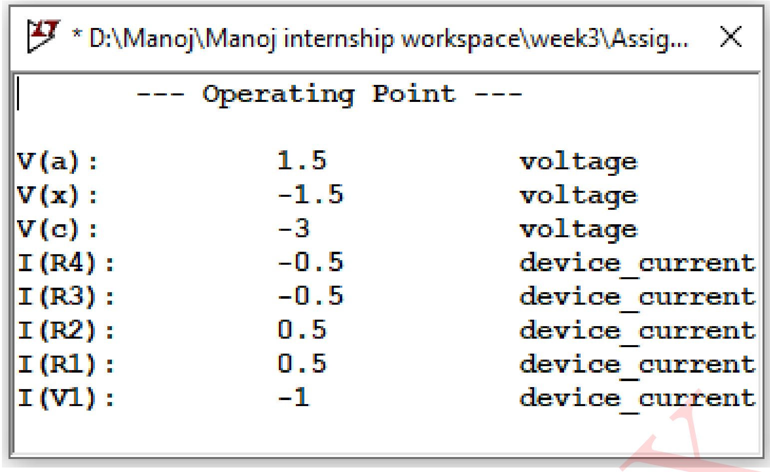


Figure 13: Circuit Schematic for V_{TH}



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--- Operating Point ---

V(a):	1.5	voltage
V(x):	-1.5	voltage
V(c):	-3	voltage
I(R4):	-0.5	device_current
I(R3):	-0.5	device_current
I(R2):	0.5	device_current
I(R1):	0.5	device_current
I(V1):	-1	device_current

Figure 14: Simulated Results for V_{TH}

RXY = RTH = V1/I(V1) = 10/2.5 = 4ohms

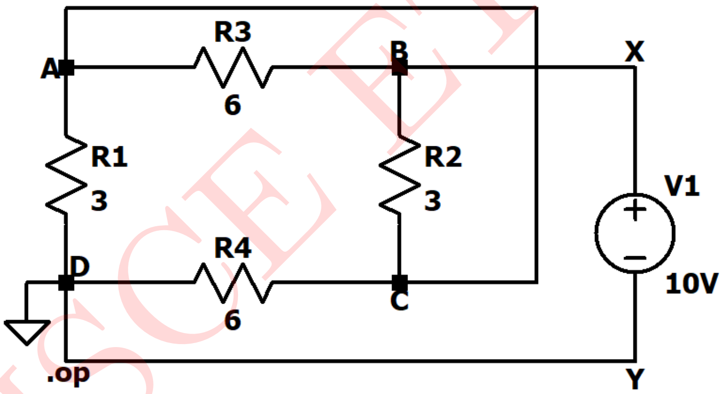

Figure 15: Circuit Schematic for R_{TH}

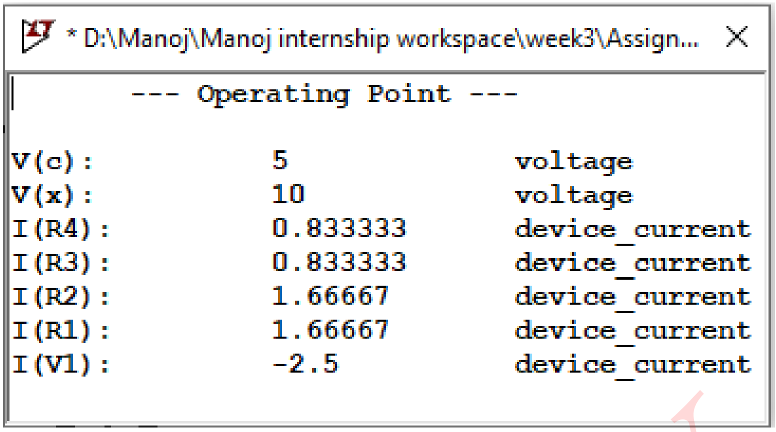

Figure 16: Simulated Results for R_{TH}

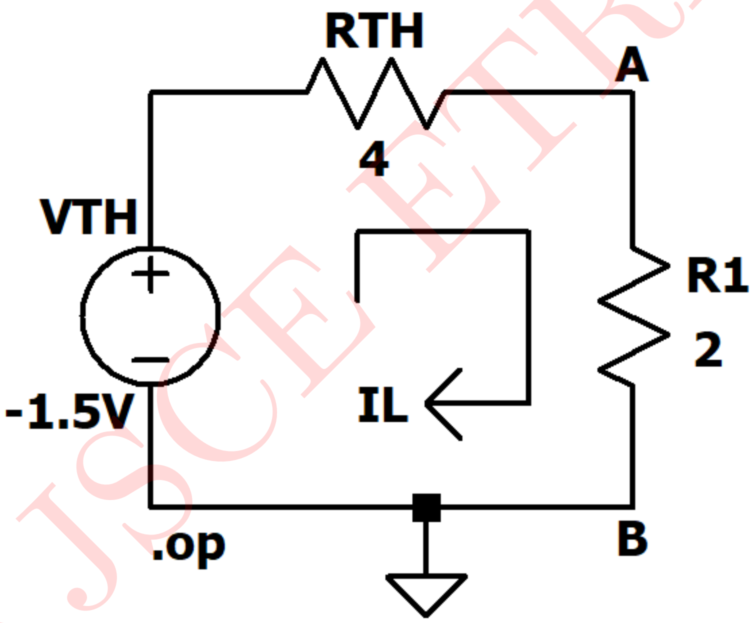

Figure 17: Circuit Schematic for I_L

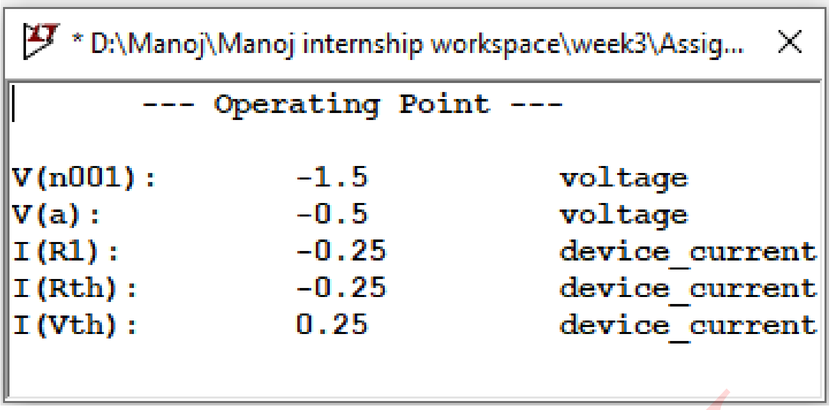

Figure 18: Simulated Results for I_L

Comparison of Theoretical and Simulated Values:-

Parameters	Theoretical Values	Simulated Values
V_{TH}	-1.5V	-1.5V
R_{TH}	4Ω	4Ω
I_L	-0.25A	-0.25A

Table 3: Numerical 3

Numerical 4: Find current in 5Ω resistor by using Thevenin's Theorem.

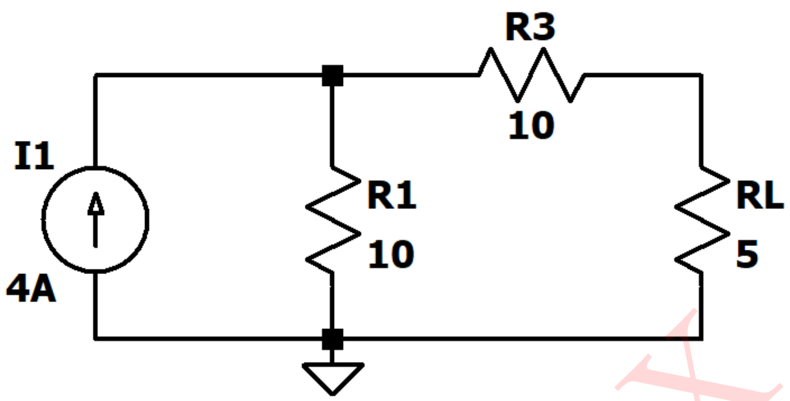

Figure 19: Circuit 4

Solution:

1) Calculation of V_{TH} :-

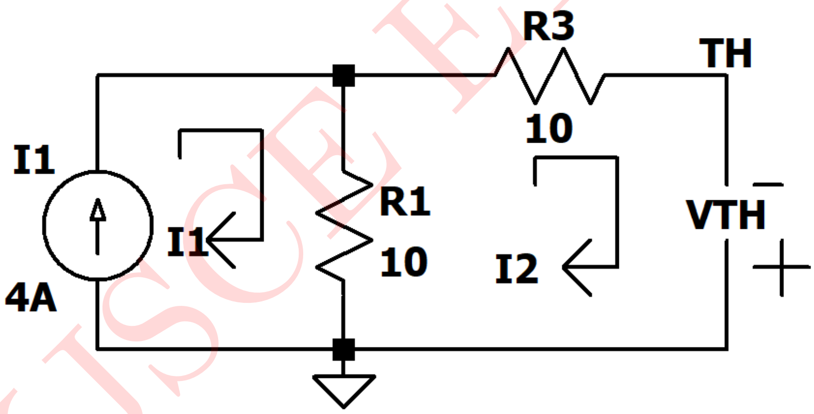

Figure 20: Circuit for V_{TH}

4A current source is in uncommon branch
$\therefore I_1 = 4\text{A}$

Applying KVL to mesh 2:
$V_{TH} = 10 \times I_1 + 10 \times 0$
$\therefore V_{TH} = 40\text{V}$

2) Calculation of R_{TH} :-

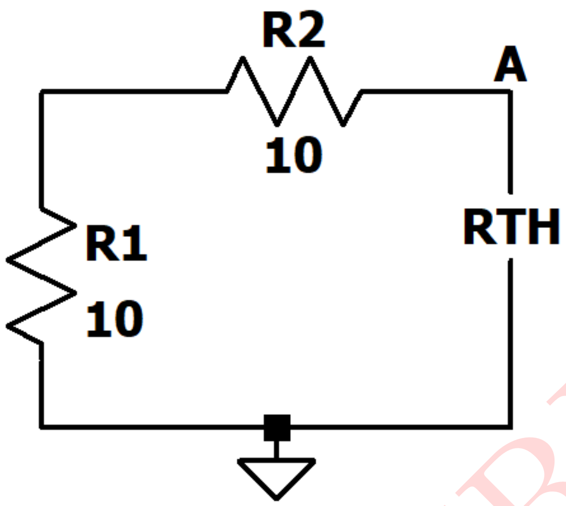

Figure 21: Circuit for R_{TH}

R_1 and R_2 are series with each other
$\therefore R_{TH} = 10 + 10$
$R_{TH} = 20\Omega$

3) Calculation of load current :-

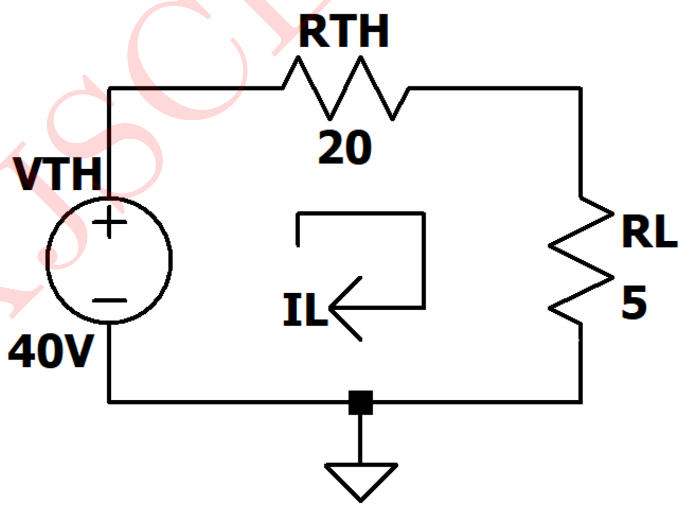

Figure 22: Thevenin's equivalent circuit

Applying KVL to mesh 1:
$40 - 20I_L - 5I_L = 0$
$40 - 25I_L = 0$
$I_L = \frac{40}{25}$
$\therefore I_L = 1.6\text{A}$

SIMULATED RESULTS:

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

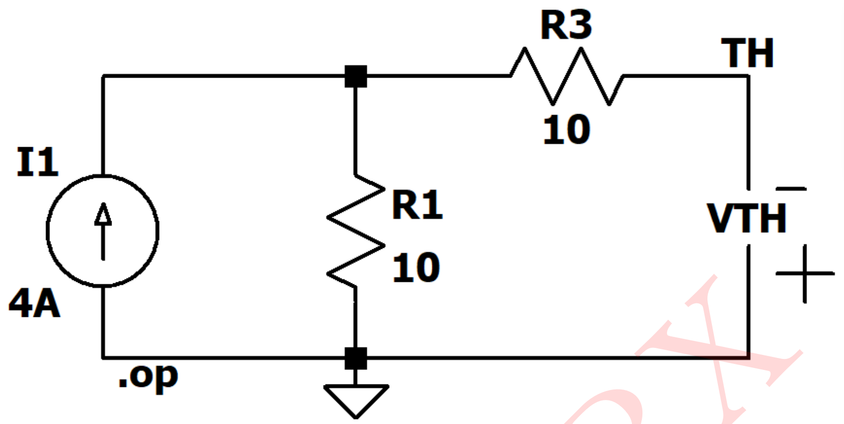

Figure 23: Circuit Schematic for V_{TH}

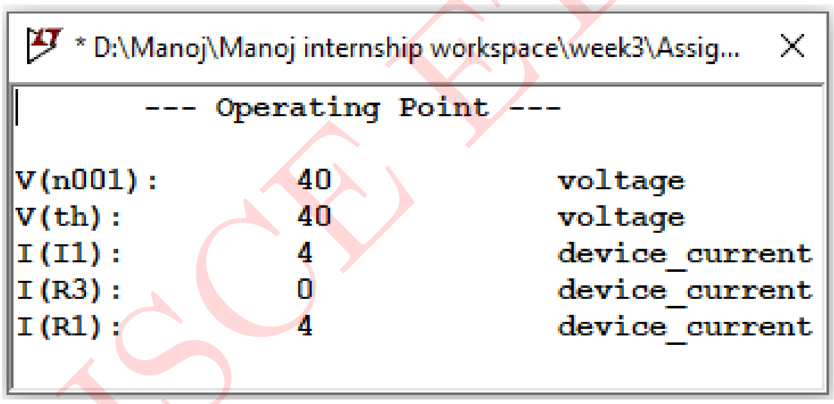

Figure 24: Simulated Results for V_{TH}

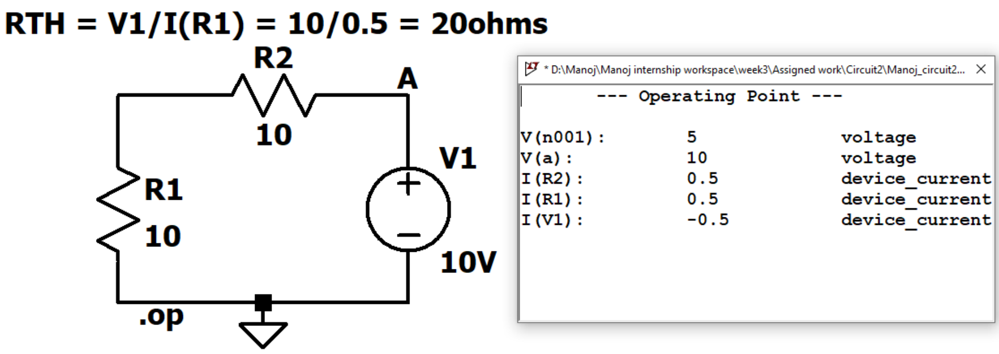

Figure 25: Circuit Schematic and Simulated Results for R_{TH}

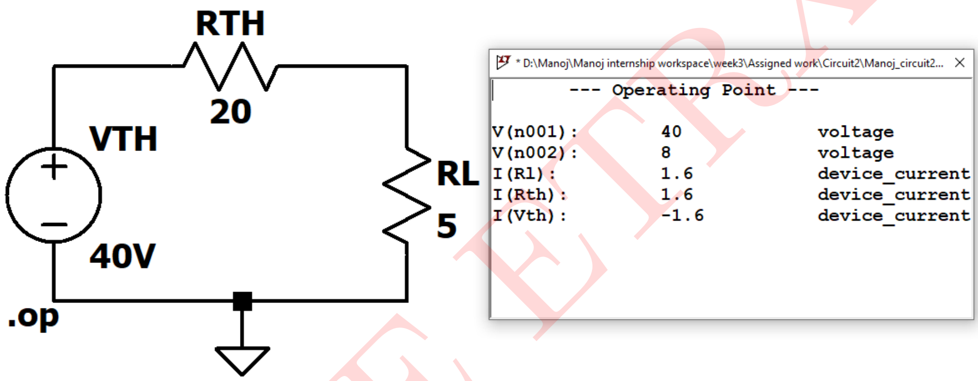

Figure 26: Circuit Schematic and Simulated Results for I_L

Comparison of Theoretical and Simulated Values:-

Parameters	Theoretical Values	Simulated Values
V_{TH}	40V	40V
R_{TH}	20Ω	20Ω
I_L	1.6A	1.6A

Table 4: Numerical 4

Numerical 5: For the circuit shown in figure 27, find the value of R_L for the maximum power transefer and also find maximum power P_{Max}

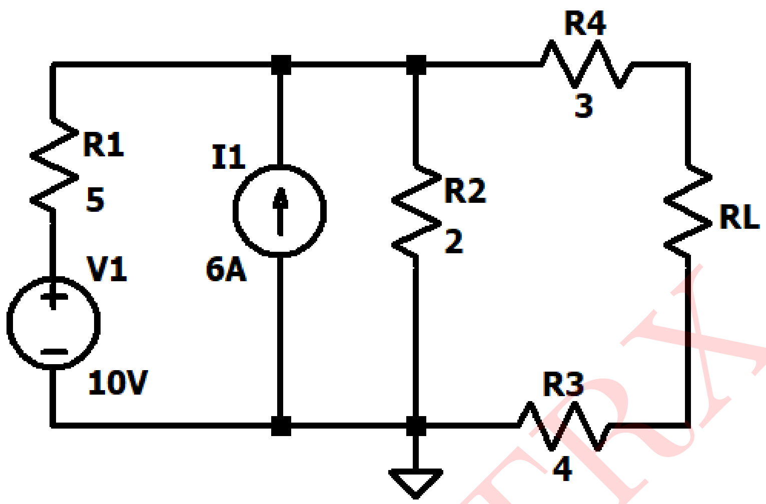

Figure 27: Circuit 5

Solution:

1) Calculation of V_{TH} :-

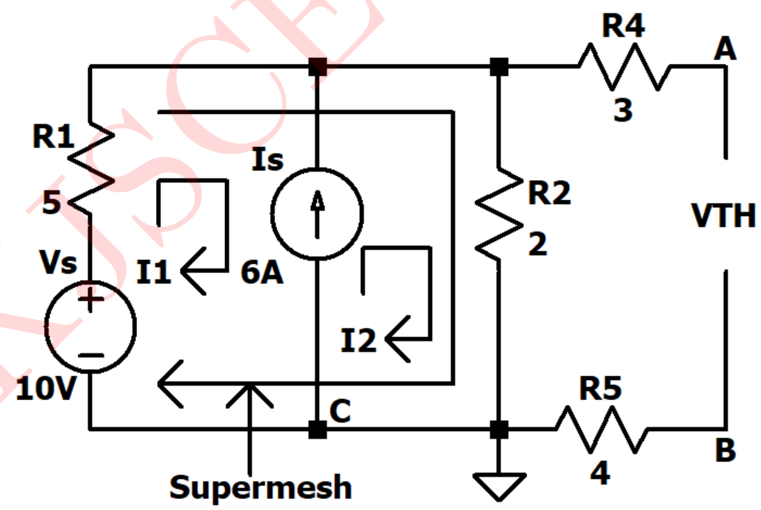

Figure 28: Circuit for V_{TH}

6A current source is in common branch
By applying KCL to node C, we get
$I_1 + 6 = I_2$
$-I_1 + I_2 = 6$ ....(1)

Applying KVL to supermesh:
$10 - 5I_1 - 2I_2 = 0$
$5I_1 + 2I_2 = 10$ ....(2)

Solving equation (1) and (2) simultaneously
$I_1 = -0.2857\text{A}$ and $I_2 = 5.7142\text{A}$

$\therefore V_{TH} = 2I_2$
$= 2 \times 5.7142$
$= 11.4284\text{V}$

2) Calculation of R_{TH} :-

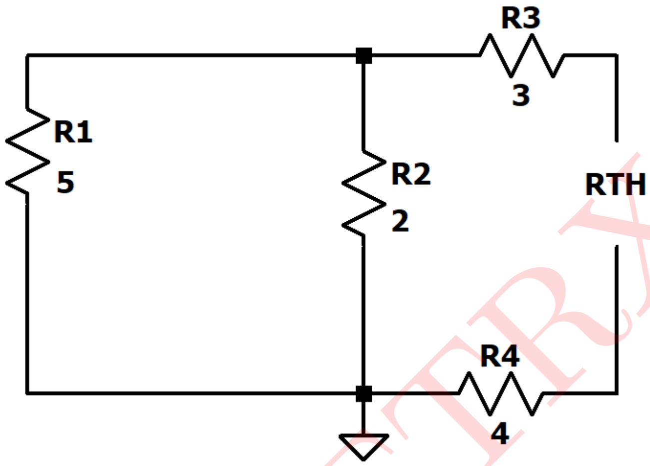

Figure 29: Circuit for R_{TH}

R_1 and R_2 resistor are parallel with each other and series with R_3 and R_4

$$\therefore R_{TH} = \frac{5 \times 2}{5+2} + 3 + 4$$
$$R_{TH} = \frac{10}{7} + 3 + 4$$
$$R_{TH} = 1.4285 + 3 + 4$$
$$\therefore R_{TH} = 8.4285\Omega$$

3) Calculation of load current :-

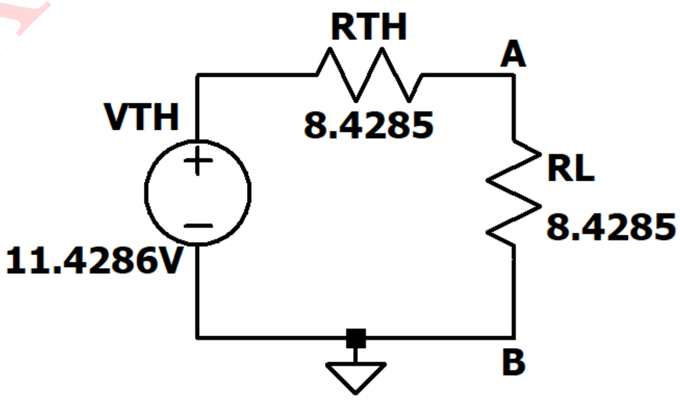

Figure 30: Thevenin's equivalent circuit

For Maximum Power:
$R_L = R_{TH} = 8.4285\Omega$
By Maximum Power Transfer Theorem

$$\therefore P_{Max} = \frac{V_{TH}^2}{4R_{TH}}$$
$$= \frac{(11.4284)^2}{4 \times 8.4285}$$
$$= \frac{130.6083}{33.714}$$
$$\therefore P_{Max} = 3.8740\text{W}$$

SIMULATED RESULTS:

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

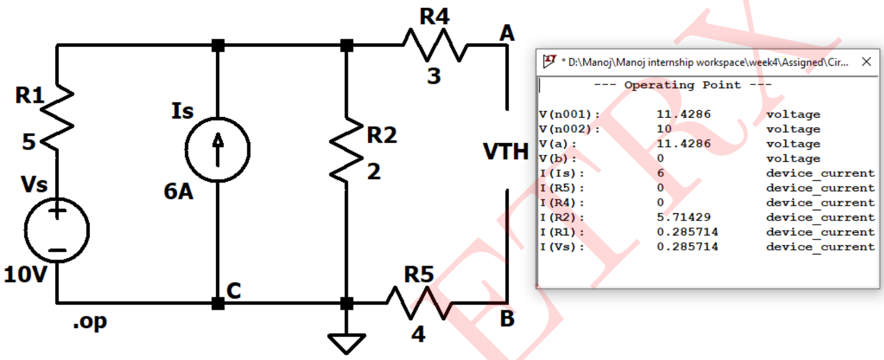

Figure 31: Circuit Schematic for V_{TH}

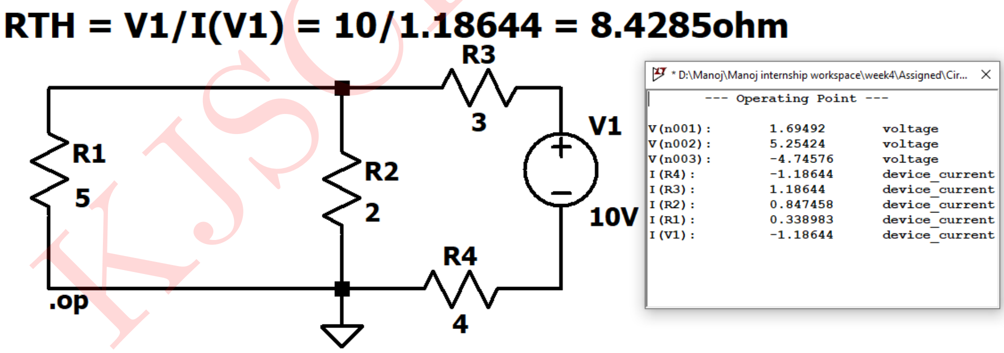

Figure 32: Circuit Schematic and Simulated Results for R_{TH}

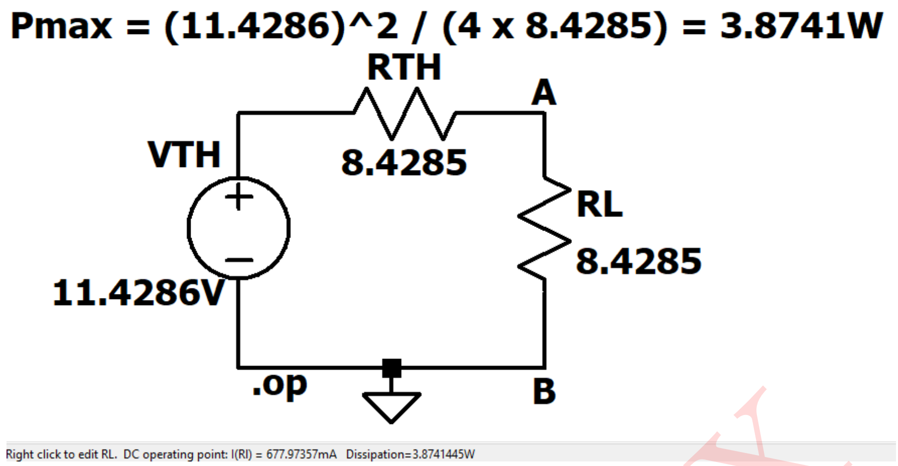

Figure 33: Circuit Schematic for P_{Max}

Comparison of Theoretical and Simulated Values:-

Parameters	Theoretical Values	Simulated Values
V_{TH}	11.4284V	11.4286V
R_{TH}	8.4285Ω	8.4285Ω
P_{Max}	3.8740W	3.8741W

Table 5: Numerical 5

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