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

Numerical 1: Find the current in 15Ω resistor using the Superposition theorem.

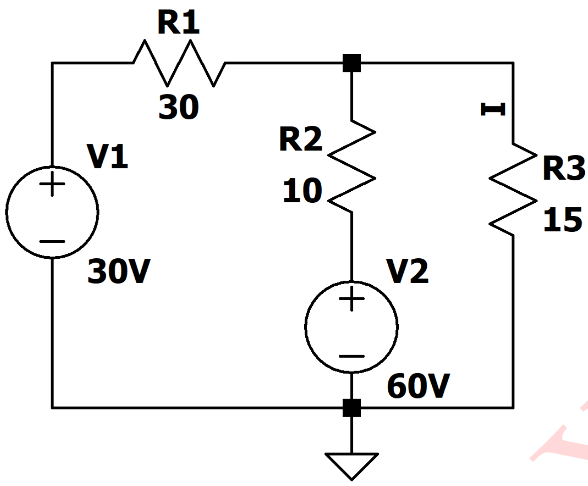

Figure 1: Circuit:1

Solution:

Using Superposition theorem:

Case 1: 60V battery is active:

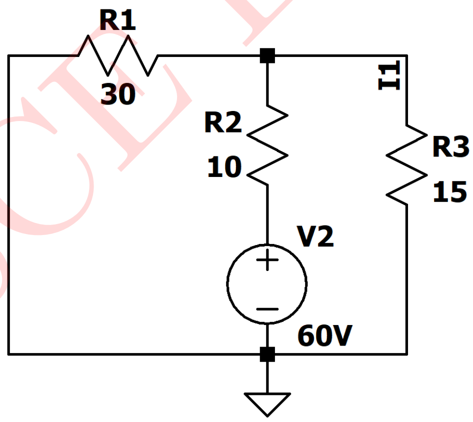

Figure 2: When 60V source is active

Simplifying the Circuit,

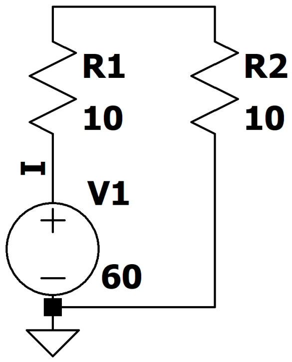

Figure 3: Simplified Circuit for Figure2

$I = \frac{60}{20}$ .. (Refer Figure 3)

$I = 3A$

Using the current divion rule,

$I_1 = \frac{3 \times 30}{45}$

$I_1 = 2A$

Case 2: 30V battery is active:

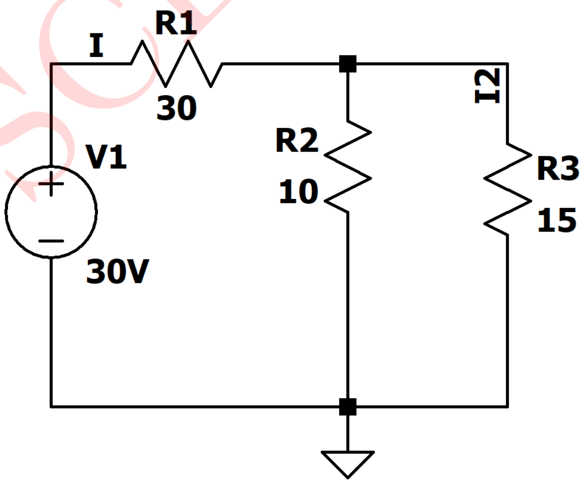

Figure 4: When 30V source is active

Simplifying the Circuit,

$I = \frac{30}{30 + (10||15)}$

$I = 0.8333A$

Using the current divison rule,

$$I_2 = \frac{10 \times 0.833}{25}$$

$$I_2 = 0.333A$$

$$\begin{aligned} \text{Current through } 15\Omega &= I1 + I2 \\ &= 2 + 0.33 \\ &= 2.333A \end{aligned}$$

SIMULATED RESULTS:

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

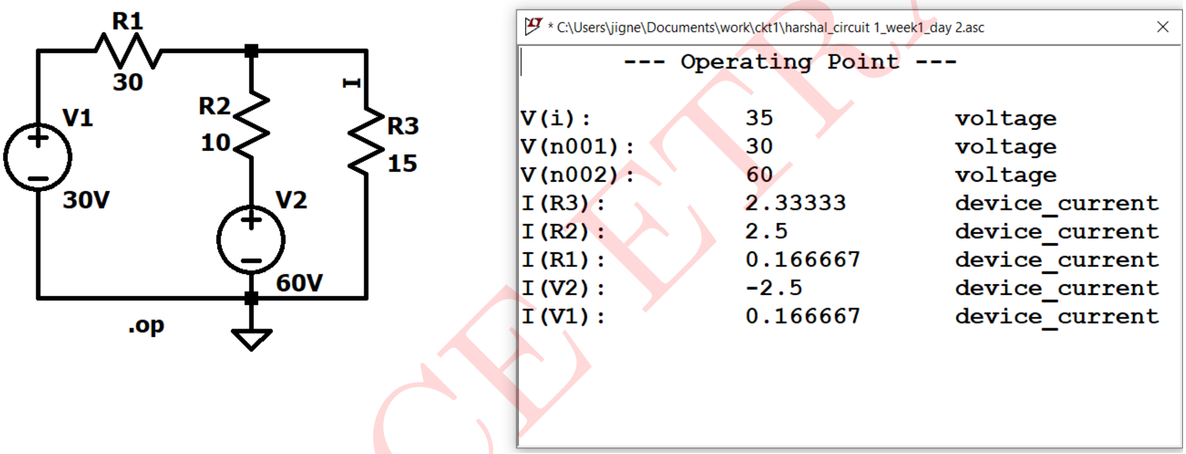

Figure 5: Circuit schematic and Simulated Results

Comparison of Theoretical and Simulated values:

Parameters	Theoretical Values	Simulated Values
$I_{15\Omega}$	$2.3333A$	$2.333A$

Table 1: Numerical 1

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Numerical 2: Find the current in 10Ω resistor using the Superposition theorem.

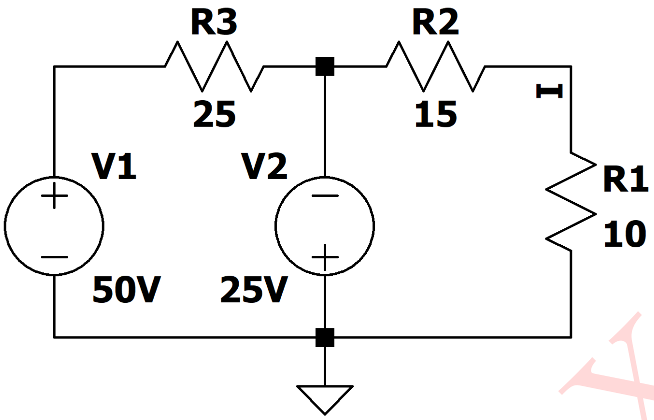

Figure 6: Circuit:2

Solution:

Using Superposition theorem:

Case 1: 50V battery is active:

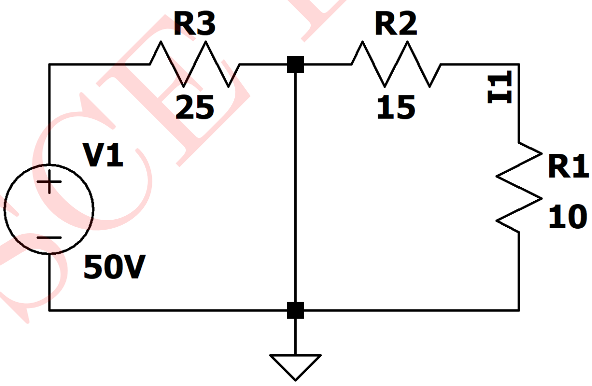

Figure 7: When 50V source is active

No current will flow through 10Ω resistor
$I_1 = 0A$

Case 2: 25V battery is active:

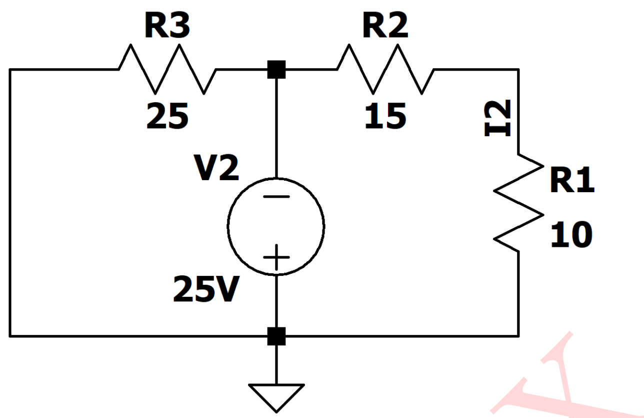

Figure 8: When 25V source is active

Simplifying the Circuit we get,

$$\text{I} = -\frac{25}{12.5}$$

$$\text{I} = -2A$$

Using the current divison rule,

$$I_2 = -\frac{25}{50}$$

$$I_2 = -1A$$

Current through 10Ω $= \text{I}_1 + I_2$

$$= 0 - 1$$

$$= -1A$$

SIMULATED RESULTS:

The following circuit was simulated in LTspice and the simulated result are as follows:

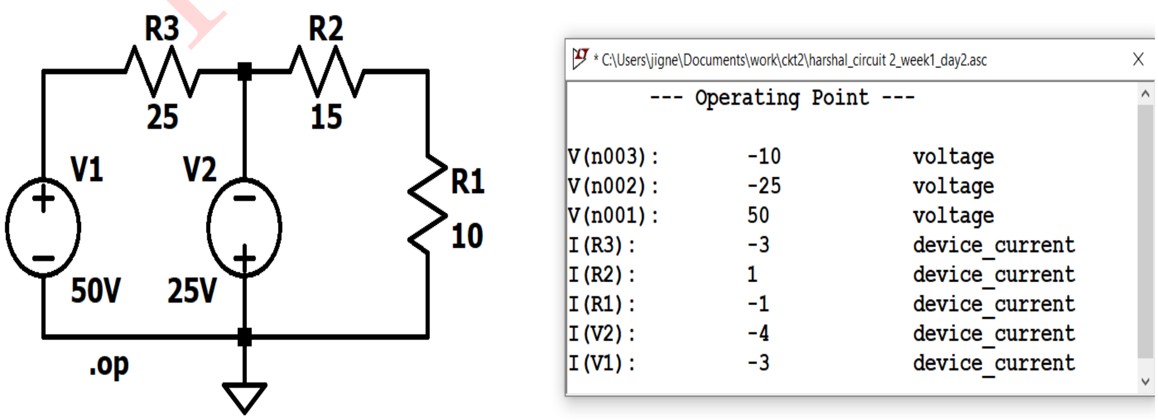

Figure 9: Circuit schematic and Simulated Result

Comparison of Theoretical and Simulated values:

Parameters	Theoretical Values	Simulated Values
$I_{10\Omega}$	$-1A$	$-1A$

Table 2: Numerical 2

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Numerical 3: **Using Thevenin's Theorem solve for the current I in the circuit 3.**

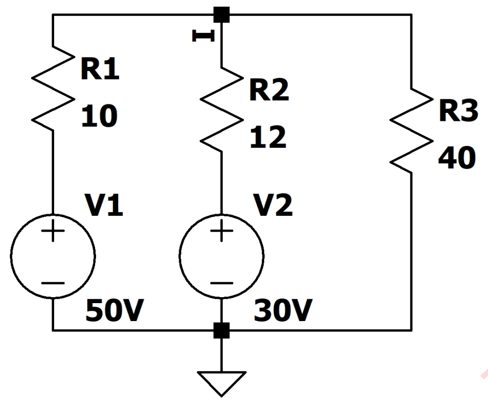

Figure 10: Circuit 3

Solution:

1) Calculation of $\mathbf{V_{Th}}$:

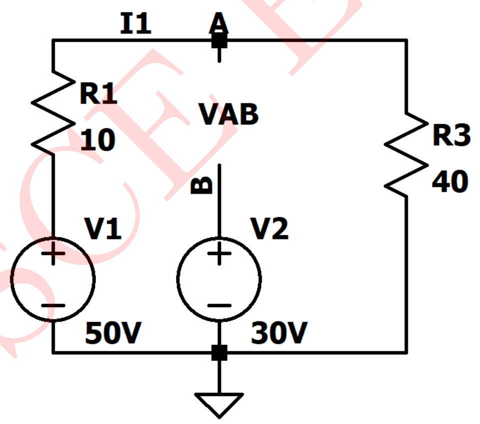

Figure 11: When 60V source is active

Applying KCL,

$50 - 10I_1 - 40I_2 = 0$
$I_1 = 1A$

For $\mathbf{V}_{Th}$,

$30 + V_{Th} - 40 = 0$
$V_{Th} = 10V$

2) Calculation of R_{Th} :

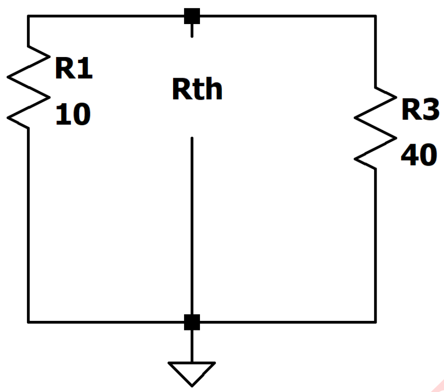

Figure 12: Circuit for R_{Th}

$R_{Th} = \dfrac{40 \times 10}{50}$

$R_{Th} = 8\Omega$

3) Calculation of I:

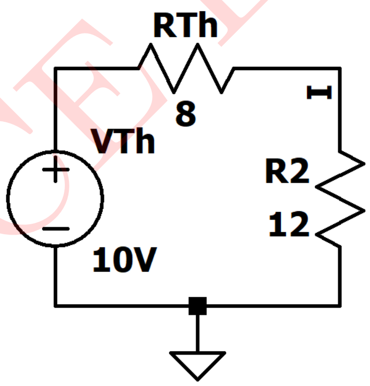

Figure 13: Circuit for calculation of I

$I = \dfrac{10}{8+12}$

$I = 0.5A$

SIMULATED RESULTS:

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

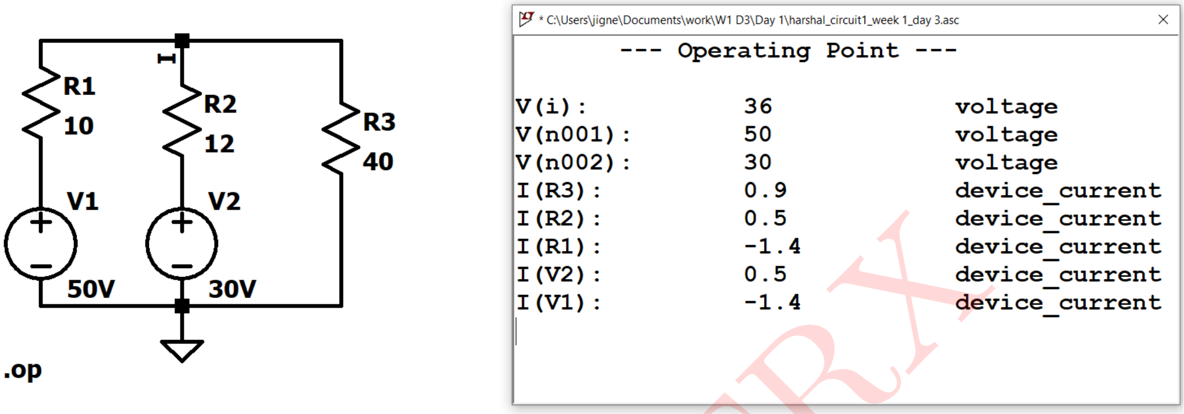

Figure 14: Circuit schematic and Simulated Results

Comparison of Theoretical and Simulated values:

Parameters	Theoretical Values	Simulated Values
$I_{12\Omega}$	$0.5A$	$0.5A$

Table 3: Numerical 3

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Numerical 4: Apply Thevenin's Theorem to find Vo in the circuit.

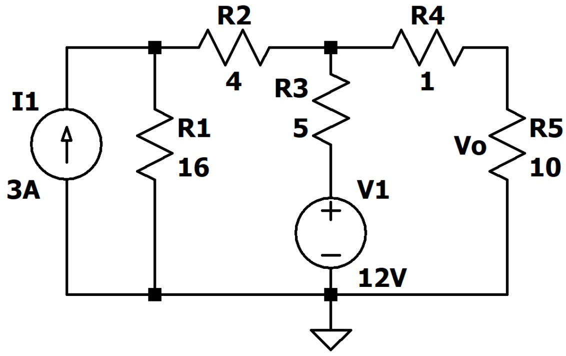

Figure 15: Circuit 4

Solution:

1) Calculation of $\mathbf{V_{Th}}$:

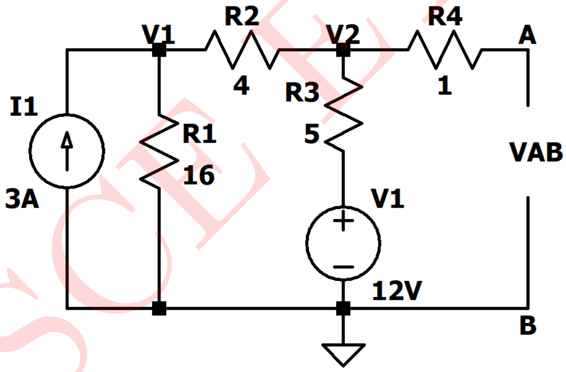

Figure 16: Circuit for calculating V_{Th}

At Node 1,

$$\mathbf{3} = \frac{V_1}{16} + \frac{V_1 - V_2}{4}$$

$5V_1 - 4V_2 = 48$ ......(1)

At Node 2:

$$\frac{V_1 - V_2}{4} + \frac{12 - V_2}{5} = \mathbf{0}$$

$-5V_1 + 9V_2 = 48$ ....(2)

Solving Equation (1) and (2),

$V_{Th} = V_2 = 19.2V$

2) Calculation of R$_{Th}$:

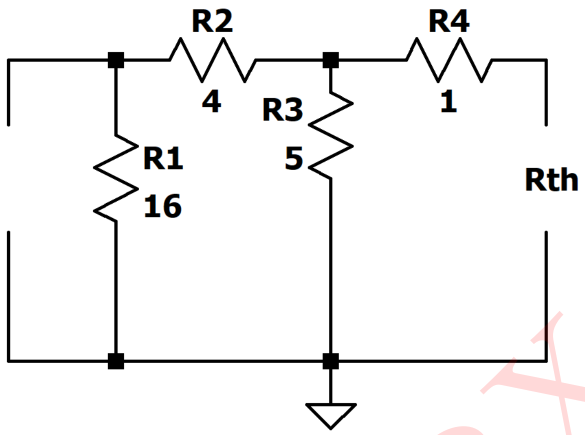

Figure 17: Circuit for R$_{Th}$

$$R_{Th} = \frac{20 \times 5}{25} + 1$$

$$R_{Th} = 5\Omega$$

3) Calculation of I:

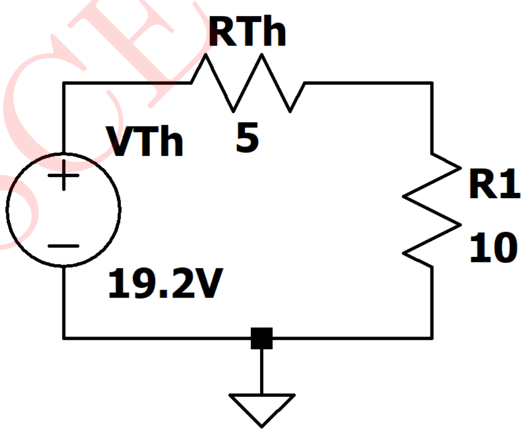

Figure 18: Circuit for calculation of I

$$I = \frac{19.2}{10 + 5}$$

$$I = 1.28A$$

SIMULATED RESULTS:

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

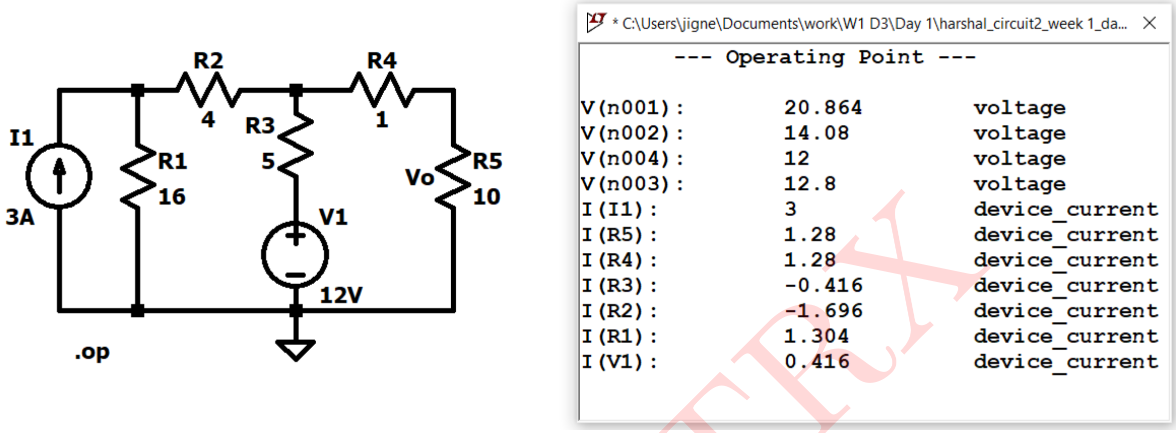

Figure 19: Circuit schematic and Simulated Results

Comparison of Theoretical and Simulated values:

Parameters	Theoretical Values	Simulated Values
V_o	$12.8V$	$12.8V$

Table 4: Numerical 4

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Numerical 5: Find the Norton's equivalent circuit between A and B.

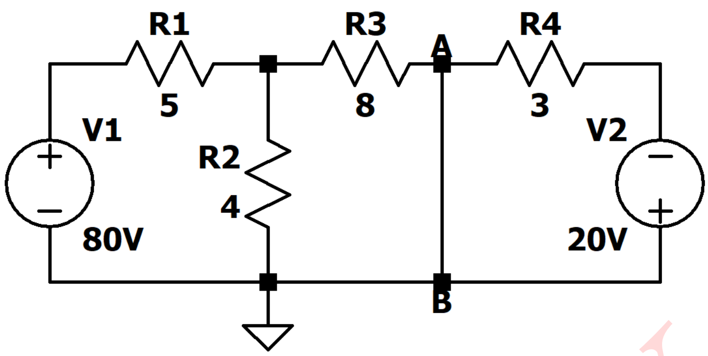

Figure 20: Circuit 5

Solution:

Step 1) Finding $\mathbf{I_N}$:

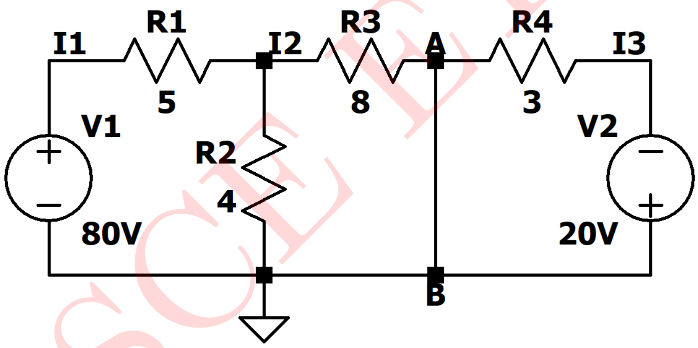

Figure 21: Circuit for calculating I_N

Applying KVL to Mesh 1,
$80 - 5I_1 - 4(I_1 - I_2) = 0$
$80 - 9I_1 + 4I_2 = 0$ **...(1)**

Applying KVL to Mesh 2,
$-4(I_2 - I_1) - 8I_2 = 0$
$4I_1 - 12I_2 = 0$ **...(2)**

Applying KVL to Mesh 3,
$20 - 3I_3 = 0$ **...(3)**

Solving equations (1), (2) & (3)
$I_2 = 3.478A$
$I_3 = 6.666A$
$\mathbf{I}_N = I_3$-I_2
$I_N = 6.666 - 3.478$
$I_N = 3.188A$

Step 2) Finding R_{Th} :

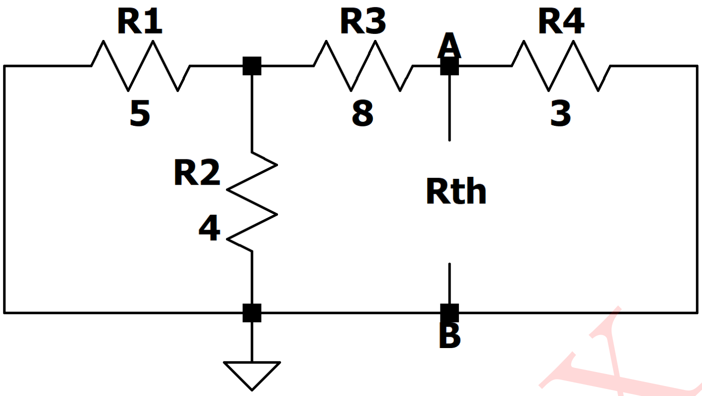

Figure 22: Circuit for R_{Th}

$R_{Th} = \frac{276}{119}$

$R_{Th} = 2.139\Omega$

Norton's Equivalent Circuit

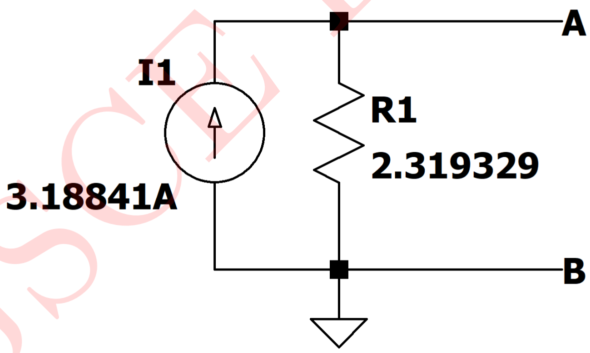

Figure 23: Norton's Equivalent Circuit

SIMULATED RESULTS: The given circuit is simulated in LTspice and the result obtained are as follows:

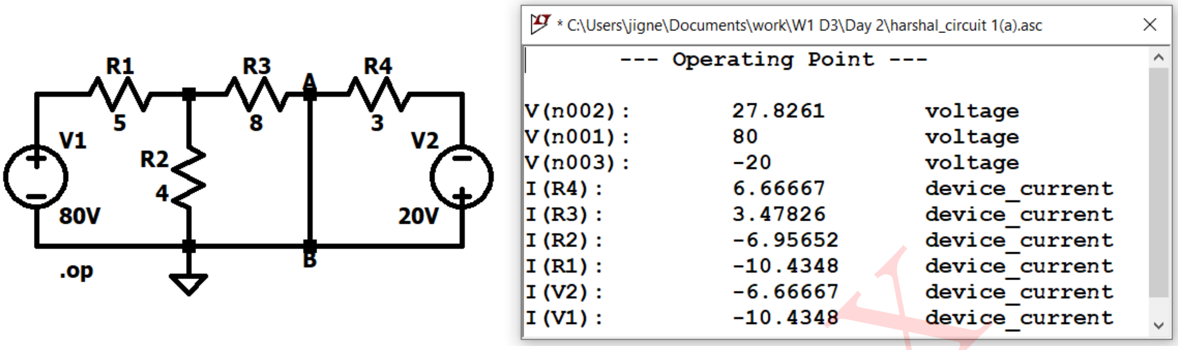

Figure 24: Circuit schematic and Simulated Results

Comparison of Theoretical and Simulated values:

Parameters	Theoretical Values	Simulated Values
I_N	$3.188A$	$3.18841A$
R_{Th}	2.319Ω	2.3193Ω

Table 5: Numerical 5

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Numerical 6: Find the current flowing through the 4Ω resistor using Thevenin's and Norton's Theorem.

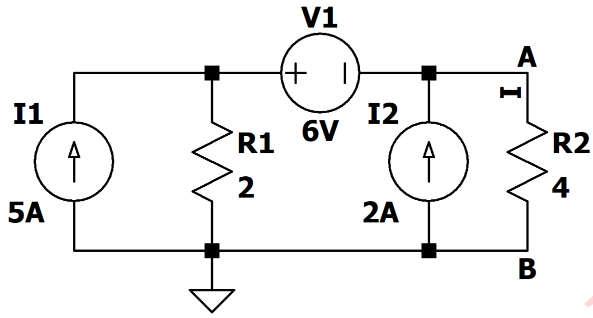

Figure 25: Circuit 6

Solution:

1) Norton's Theorem
Step 1): Finding I_N

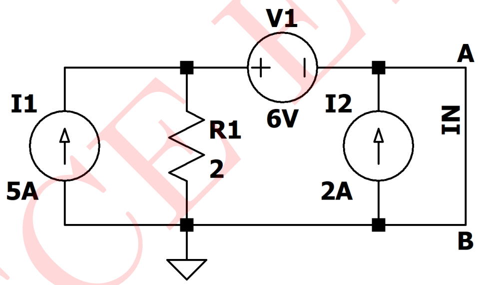

Figure 26: Circuit for calculating I_N

For Mesh 1,
$I_1 = 5A$ **...(1)**

For the supermesh,
$-2(I_2 - 5) - 6 = 0$
$I_N = 2A$ **...(2)**
$\therefore I_N = I_2 + 1$
$I_N = 4A$

Step 2) Finding $\mathbf{R_{Th}}$:

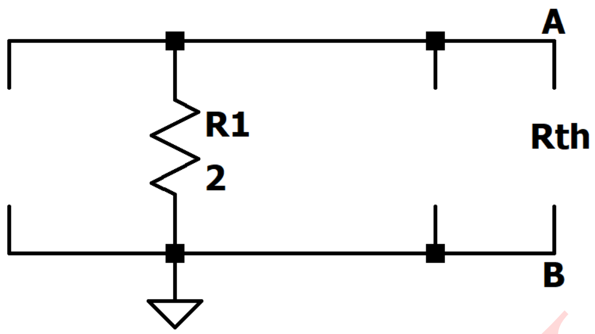

Figure 27: Circuit for R_{Th}

$R_{Th} = 2\Omega$ **...(3)**

Step 3) Norton's Equivalent Circuit:

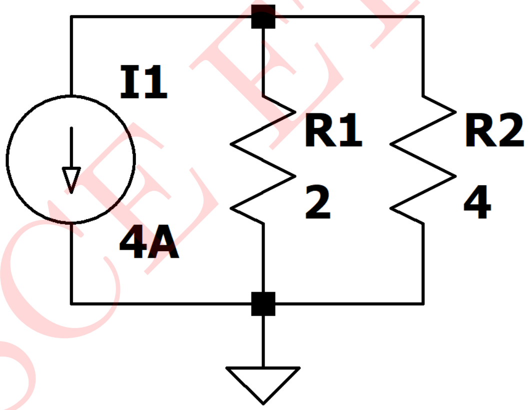

Figure 28: Norton's Equivalent Circuit

$$I_{4\Omega} = \frac{2 \times 4}{6}$$

$$I_{4\Omega} = 1.33A$$

2) Thevenin's Theorem:

Step 1): Find $\mathbf{V_{Th}}$,

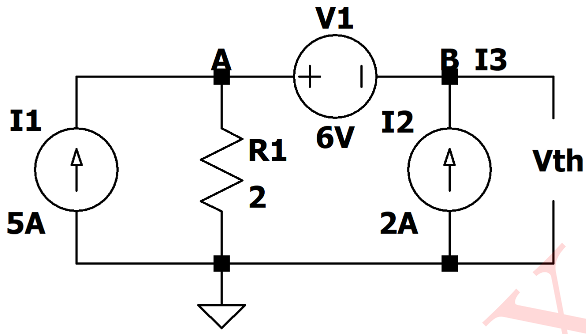

Figure 29: Circuit for calculating V_{TH}

From Mesh 1,

$I_1 = 5A$
$I_3 - I_2 = 2A$
$I_2 = 2A$ ...(From (2))
$V_{TH} + 6 - 2(5 + 2) = 0$
$V_{TH} = 8V$

Step 2):Finding $\mathbf{R}_{TH}$,
$R_{TH} = 2\Omega$ ...(From(3))

Step 3): Calculating I,

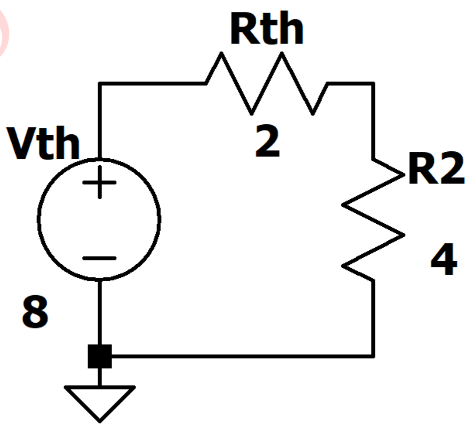

Figure 30: Thevenin's Equivalent Circuit

SIMULATED RESULTS: The given circuit is simulated in LTspice and the result obtained are as follows:

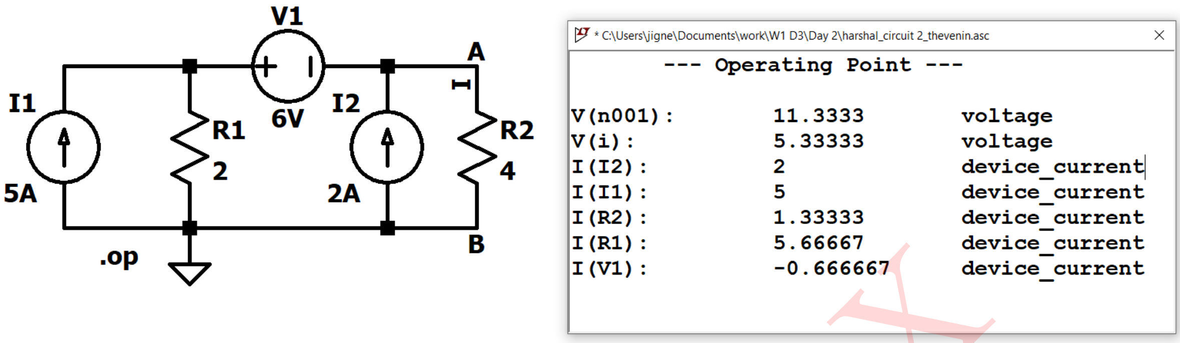

Figure 31: Circuit schematic and Simulated Results

Comparison of Theoretical and Simulated values:

Parameters	Theoretical Values	Simulated Values
$I_{4\Omega}$ (Norton's Theorem)	1.33Ω	1.33Ω
$I_{4\Omega}$ (Thevenin's Theorem)	1.333Ω	1.33Ω

Table 6: Numerical 6

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Numerical 7: Find the current in 1kΩ resistor using Norton's Theorem.

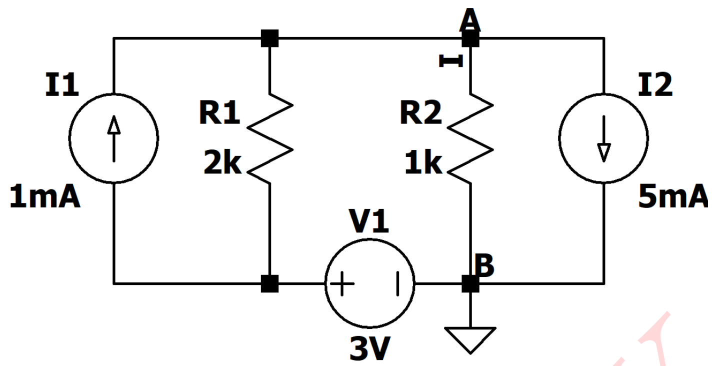

Figure 32: Circuit 7

Solution:

Step 1) Finding $\mathbf{I_N}$:

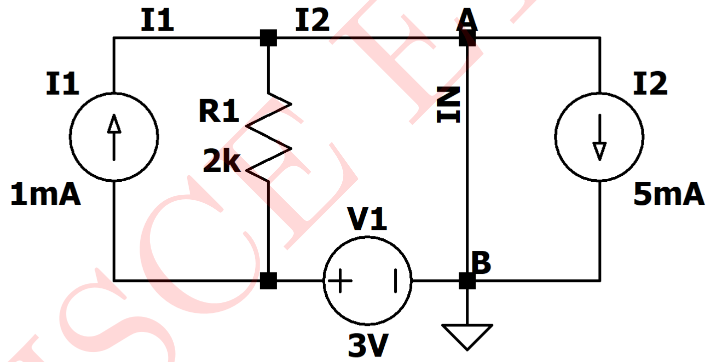

Figure 33: Circuit for calculating I_N

$I_1 = 1mA$

For Mesh 2,
$3 - 2(I_2 - 1) = 0$
$I_2 = 2.5mA$
$I_N = (5 - 2.5)mA$
$I_N = 2.5mA$

Step 2) Finding $\mathbf{R_{Th}}$:

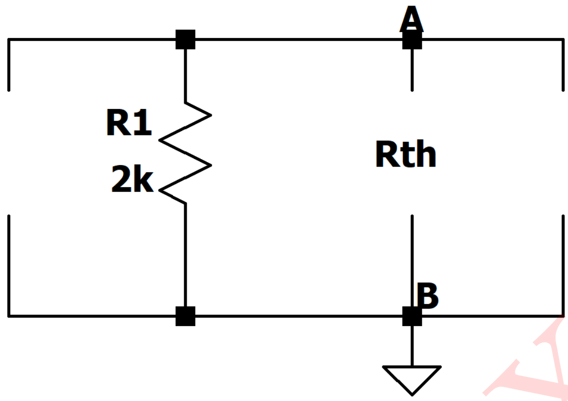

Figure 34: Circuit for R_{Th}

$R_{Th} = 2k\Omega$

Step 3) Finding $\mathbf{I_{1k\Omega}}$:

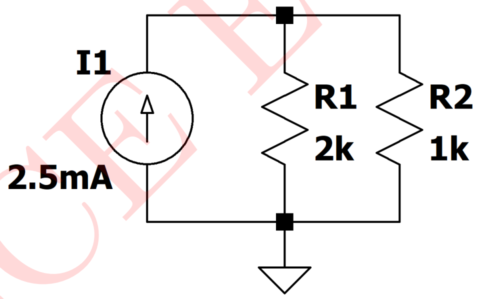

Figure 35: Norton's Equivalent Circuit

$$I_{1k\Omega} = \frac{2.5 \times 2}{3}$$

$$I_{1k\Omega} = 1.66A$$

SIMULATED RESULTS:
The given circuit is simulated in LTspice and the result obtained are as follows:

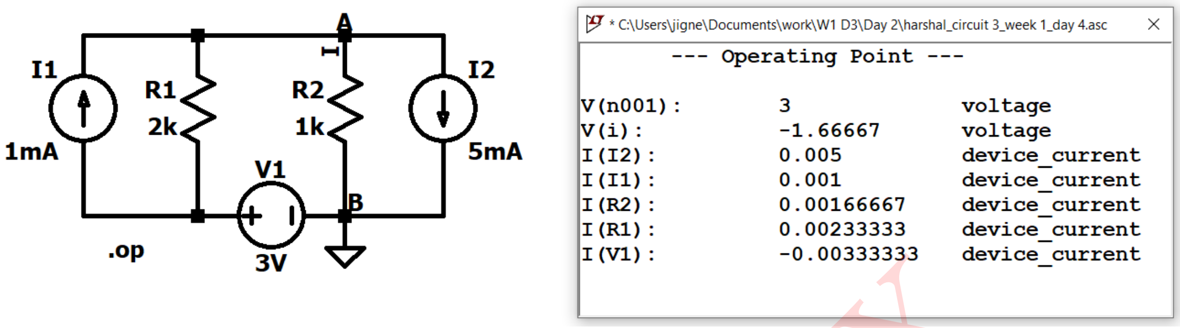

Figure 36: Circuit schematic and Simulated Results

Comparison of Theoretical and Simulated values:

Parameters	Theoretical Values	Simulated Values
$I_{1k\Omega}$	$1.666mA$	$1.666mA$

Table 7: Numerical 7

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Numerical 8: Find the maximum power in R_L of circuit 1.

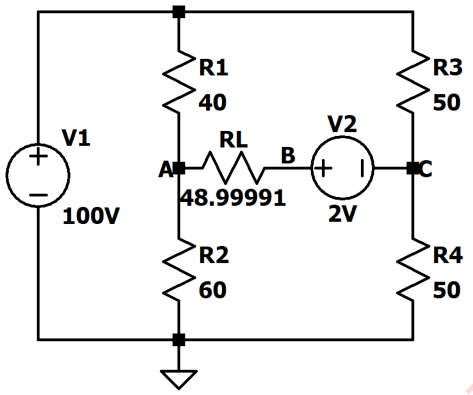

Figure 37: Circuit 8

Solution:

Step1 : Finding $\mathbf{V_{TH}}$

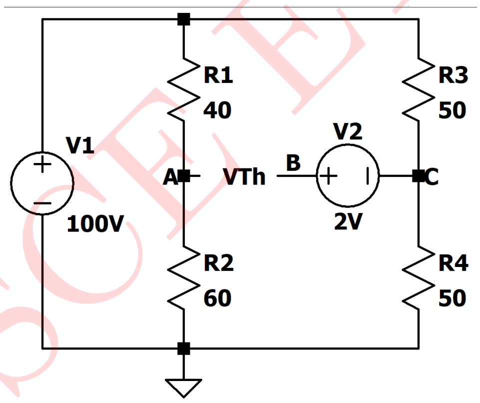

Figure 38: Circuit for finding V_{TH}

Applying KCL at node A

$$\mathbf{0} = \frac{V_A}{60} + \frac{V_A - 100}{40}$$

$V_A = 60V$

Applying KCL at node B

$$\mathbf{0} = \frac{V_C}{50} + \frac{V_C - 100}{40}$$

$V_C = 50V$

$V_B = V_C + 2$

$\mathbf{V}_B = 52V$

$V_{TH} = V_A - V_B$

$V_{TH} = 60 - 52$

$V_{TH} = 8V$

Step 2 : Finding R_{TH}

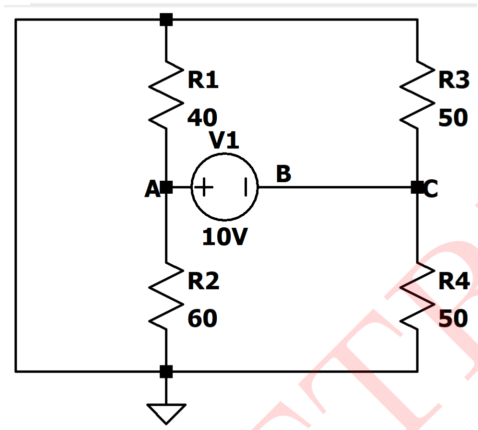

Figure 39: Circuit for finding R_{TH}

$R_{TH} = (60||40) + (50||50)$

$R_{TH} = 49\Omega$

Step 3: Calculating Maximum Power

For maximum power transfer $R_L = R_{TH} = 48.99991\Omega$

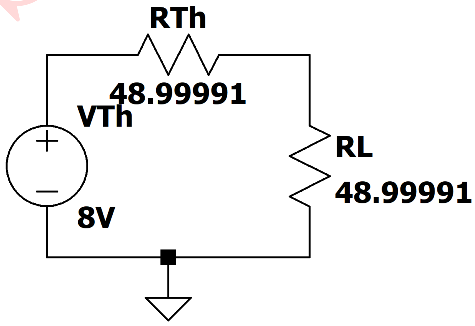

Figure 40: Circuit for Maximum Power

$Power = I^2 \times R_L$

$= (0.0816)^2 \times 49$

$Power = 0.3262W$

SIMULATED RESULTS:
The given circuit is simulated in LTspice and the result obtained are as follows:

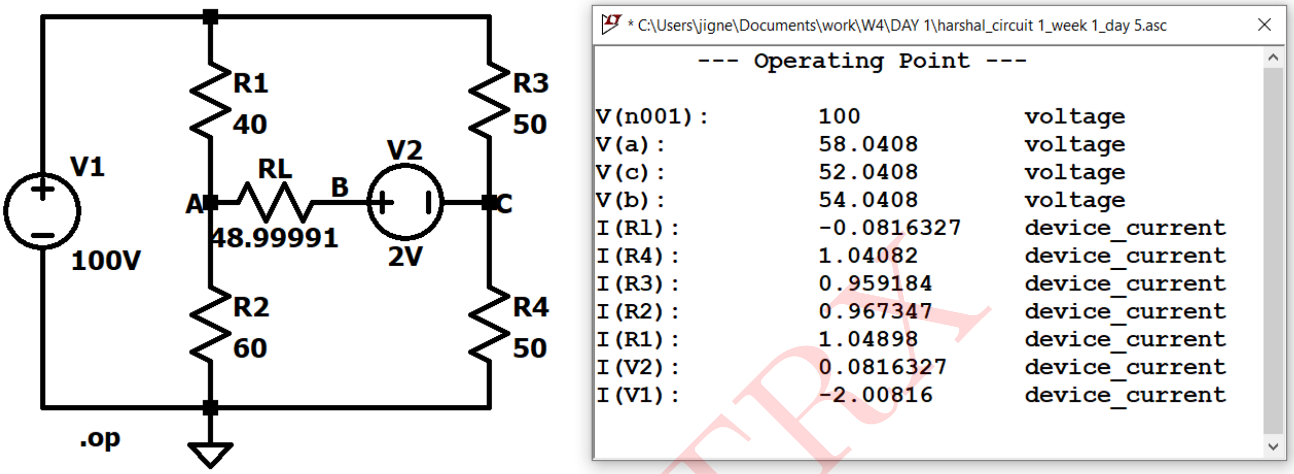

Figure 41: Circuit schematic and Simulated Results

Comparison of Theoretical and Simulated values:

Parameters	Theoretical Values	Simulated Values
P_{R_L}	0.3262W	0.3262W

Table 8: Numerical 8

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Numerical 9: Determine maximum power that can be delivered to variable resistance R$_L$.

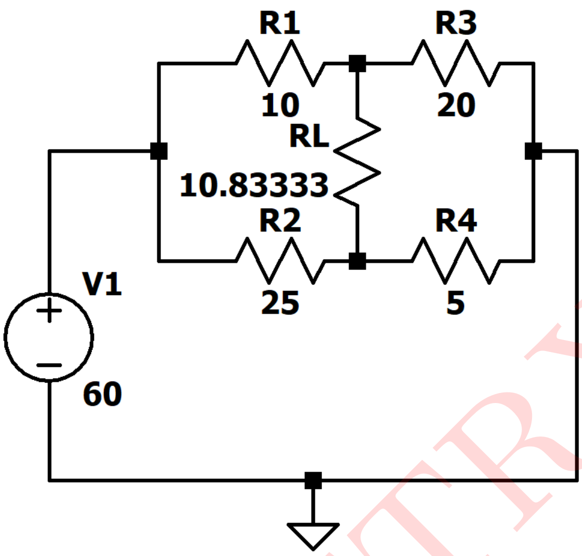

Figure 42: Circuit 9

Solution:

Step1: Finding V$_{TH}$

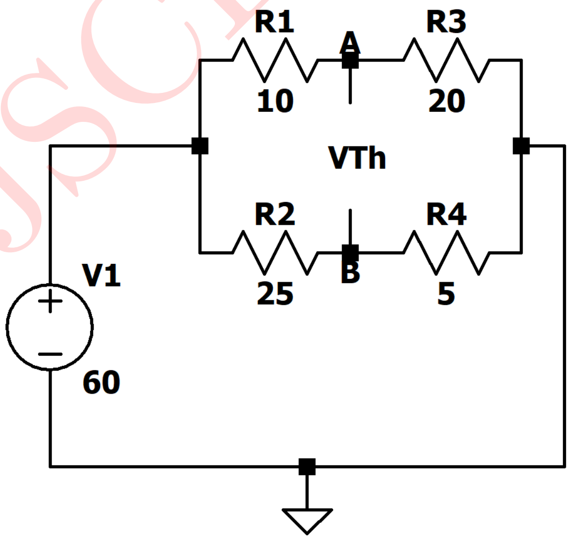

Figure 43: Circuit for calculating V$_{TH}$

Applying KCL at node A

$$\mathbf{0} = \frac{V_A}{20} + \frac{V_A - 60}{10}$$

$$V_A = \frac{120}{3}$$

$$V_A = 40V$$

Applying KCL at node B

$\mathbf{0} = \frac{V_B}{5} + \frac{V_B - 60}{25}$

$V_B = \frac{60}{6}$

$V_B = 10V$

$V_{TH} = V_B - V_A$
$V_{TH} = 40 - 10$
$V_{TH} = 30V$

Step 2 : Finding $\mathbf{R_{TH}}$

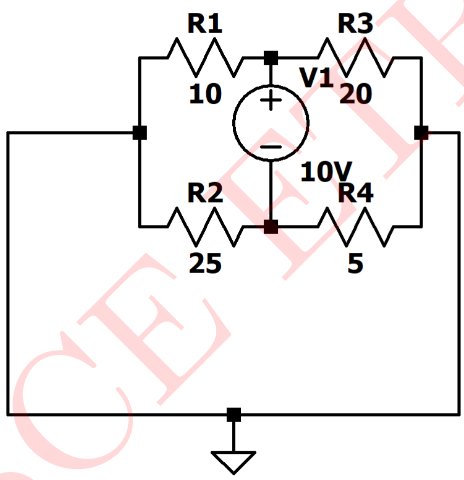

Figure 44: Circuit for finding R_{TH}

$R_{TH} = (20||10) + (25||5)$

$R_{TH} = \frac{200}{30} + \frac{125}{30}$

$R_{TH} = 10.833\Omega$

Step 3: Calculating Maximum Power

$For\ maximum\ power\ transfer\ R_L = R_{TH} = 10.833\Omega$

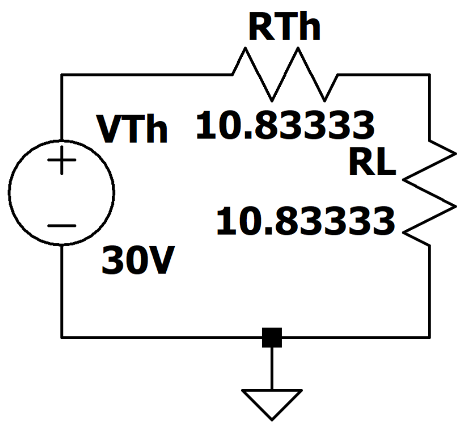

Figure 45: Circuit for Maximum Power

$$\begin{aligned} Power &= I^2 \times R_L \\ &= (1.389)^2 \times 10.833 \\ Power &= 20.769W \end{aligned}$$

SIMULATED RESULTS:

The given circuit is simulated in LTspice and the result btained are as follows:

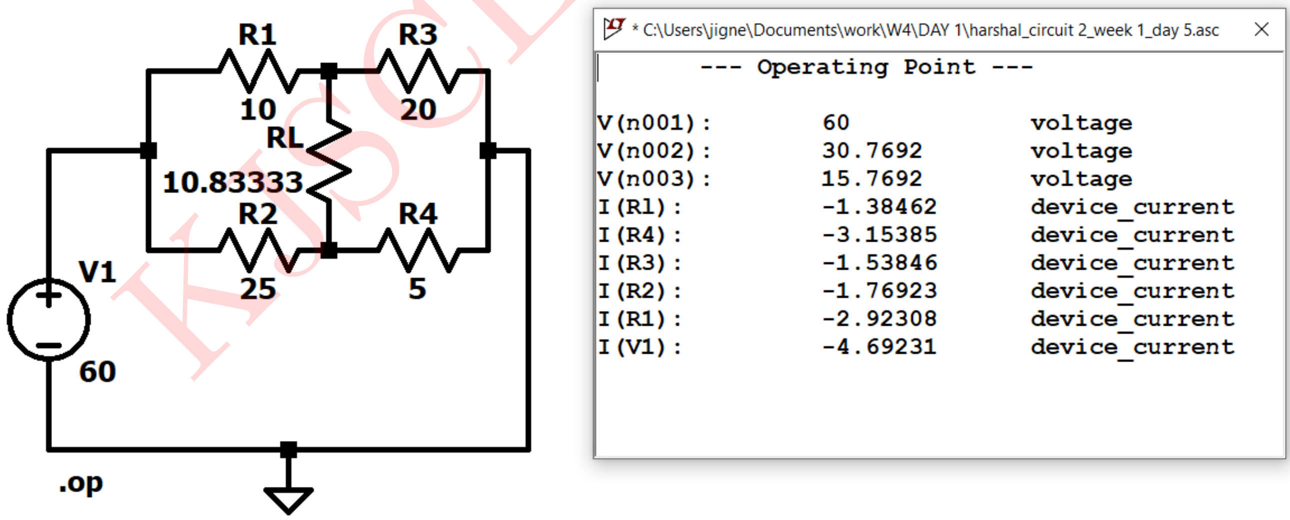

Figure 46: Circuit schematic and Simulated Results

Comparison of Theoretical and Simulated values:

Parameters	Theoretical Values	Simulated Values
P_{R_L}	20.769W	20.7693W

Table 9: Numerical 9

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