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

Numerical 1:

Find the voltage of point A w.r.t point B in the Figure 1. Is it positive w.r.t B?

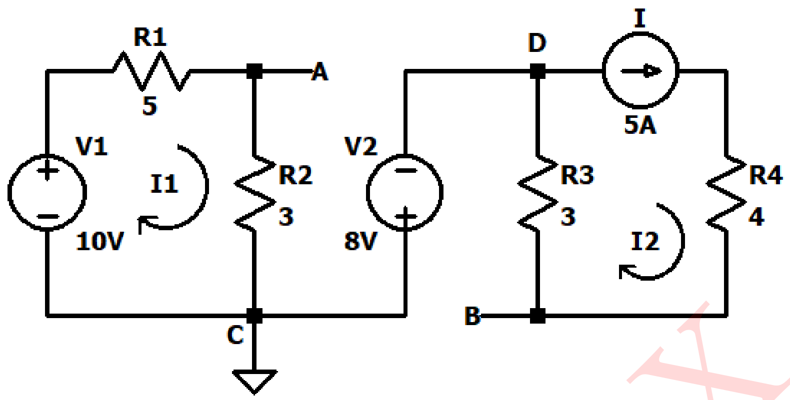

Figure 1: Circuit 1

Solution:

In the circuit 1,

For loop 1;

$I_1 = \frac{V_1}{R_1 + R_2} = \frac{10}{5+3} = 1.25A$ ...(By Ohm's Law)

For loop 2;

$I_2 = I = 5A$ ...(From circuit 1)

Applying KVL to the path from A to B,

$V_A - 3I_1 - 8 + 3I_2 - V_B = 0$

$V_A - 3 \times 1.25 - 8 + 3 \times 5 - V_B = 0$

$V_A - V_B = -3.25V$

$\therefore V_{AB} = -\mathbf{3.25V}$

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SIMULATED RESULTS:

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

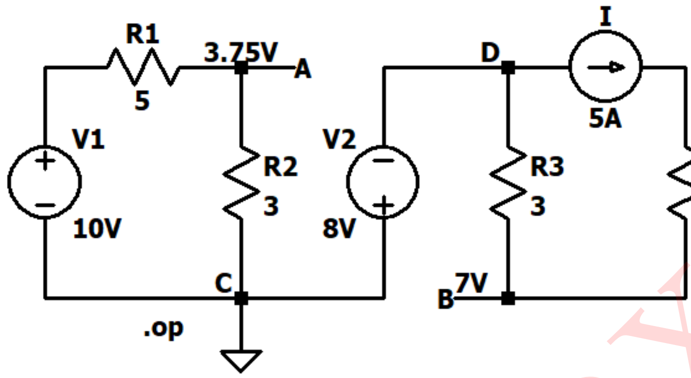
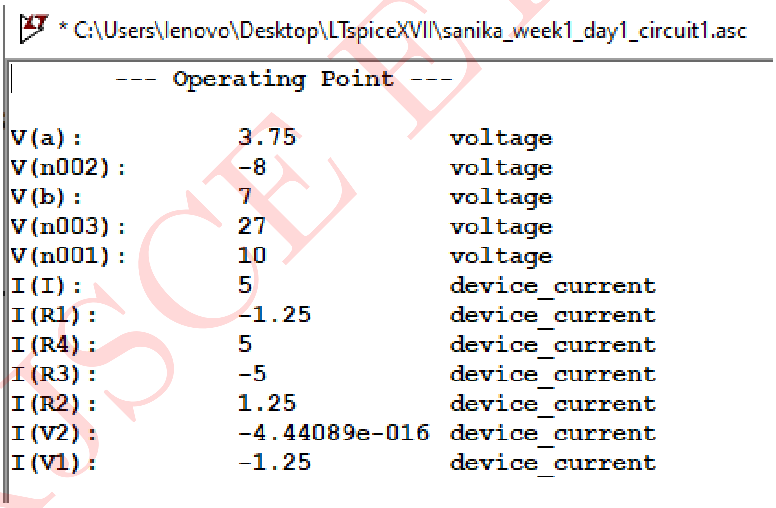


Figure 2: Circuit Schematic

Simulated results are shown in Figure 3.



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       --- Operating Point ---

V(a):          3.75           voltage
V(n002):       -8             voltage
V(b):          7              voltage
V(n003):       27             voltage
V(n001):       10             voltage
I(I):          5              device_current
I(R1):         -1.25          device_current
I(R4):         5              device_current
I(R3):         -5             device_current
I(R2):         1.25           device_current
I(V2):         -4.44089e-016  device_current
I(V1):         -1.25          device_current
```

Figure 3: Simulated Results

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
I_1	1.25A	1.25A
I_2	5A	5A
V_A	3.75V	3.75V
V_B	7V	7V

Table 1: Numerical 1

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Numerical 2:

Find the value of V_{R_1} in the circuit of Figure 4.

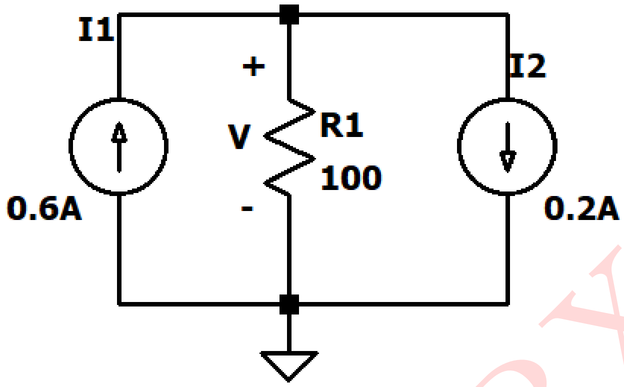

Figure 4: Circuit 2

Solution:

$I_1 = 0.6A,\ I_2 = 0.2A$ ...(From Circuit 2)

Applying KVL to circuit 2,

$V_{R_1} - 100(I_1 - I_2) = 0$

$V_{R_1} = 100{\times}(0.6{-}0.2)$

$V_{R_1} = 100{\times}0.4$

$\therefore V_{R_1} = \mathbf{40V}$

SIMULATED RESULTS:

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

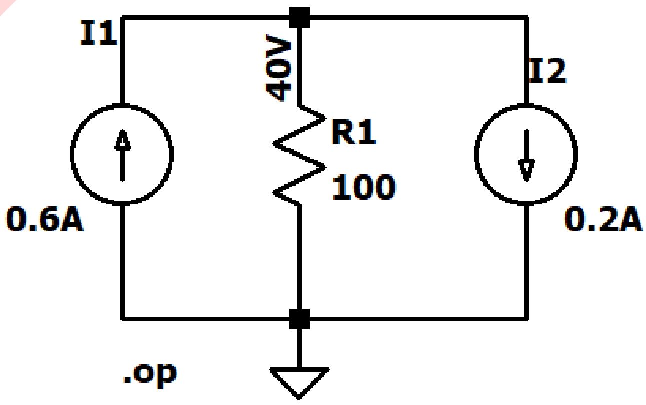

Figure 5: Circuit Schematic

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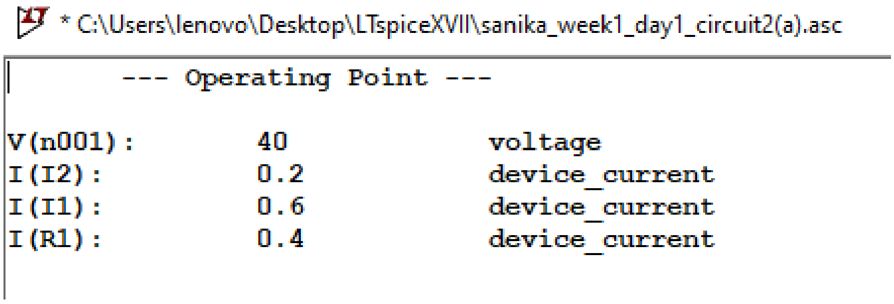
Simulated results are shown in Figure 6.



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* C:\Users\lenovo\Desktop\LTspiceXVII\sanika_week1_day1_circuit2(a).asc

       --- Operating Point ---

V(n001):        40              voltage
I(I2):          0.2             device_current
I(I1):          0.6             device_current
I(R1):          0.4             device_current
```

Figure 6: Simulated Results

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
V_{R_1}	40V	40V

Table 2: Numerical 2

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Numerical 3:

Find the value of V_1, V_2 in the circuit of Figure 7.

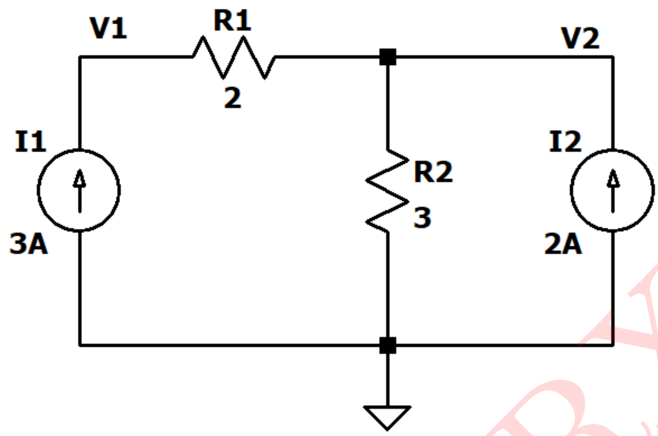

Figure 7: Circuit 3

Solution:

$I_1 = 3A$, $I_2 = 2A$ ...(From Circuit 3)

Applying KVL to circuit 3,

$V_1 - 3(I_1 + I_2) - 2I_1 = 0$

$V_2 - 3(I_1 + I_2) = 0$

$\therefore V_1 = 15 + 6 = \mathbf{21V}$

$\therefore V_2 = \mathbf{15V}$

SIMULATED RESULTS:

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

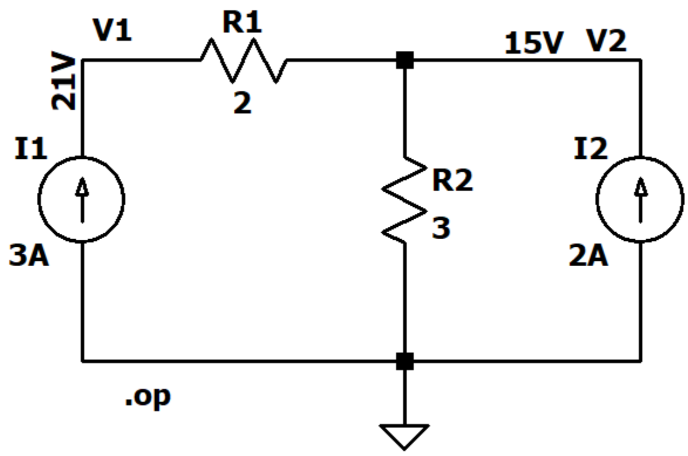

Figure 8: Circuit Schematic

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Simulated results are shown in Figure 9.

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       --- Operating Point ---

V(n002):       15            voltage
V(n001):       21            voltage
I(I2):         2             device_current
I(I1):         3             device_current
I(R2):         5             device_current
I(R1):         -3            device_current
```

Figure 9: Simulated Results

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
V_1	21V	21V
V_2	15V	15V

Table 3: Numerical 3

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Numerical 4:

Find the value of i_1, i_2 in the circuit of Figure 10.

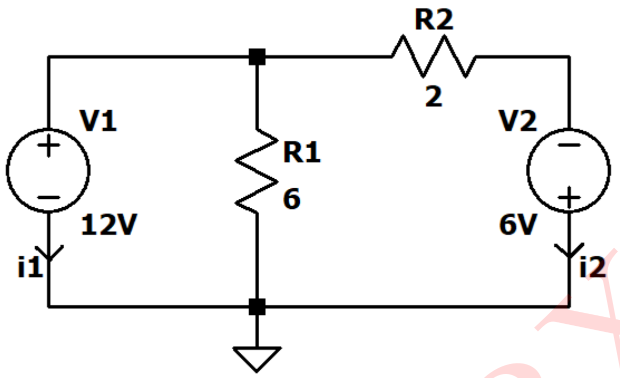

Figure 10: Circuit 4

Solution:

$V_1 = 12V$, $V_2 = 6V$ ...(From Circuit 4)

Applying KVL to loop 1 in circuit 4,

$V_1 + 6(i_1 + i_2) = 0$

$\therefore i_1 + i_2 = -2$ ...(1)

Applying KVL to loop 2 in circuit 4,

$6(i_1 + i_2) + 2i_2 = 6$

$6i_1 + 8i_2 = 6$

$3i_1 + 4i_2 = 3$ ...(2)

Solving (1) and (2) simultaneously,

$\therefore i_2 = \mathbf{9A}$ $\therefore i_1 = \mathbf{-11A}$

SIMULATED RESULTS:

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

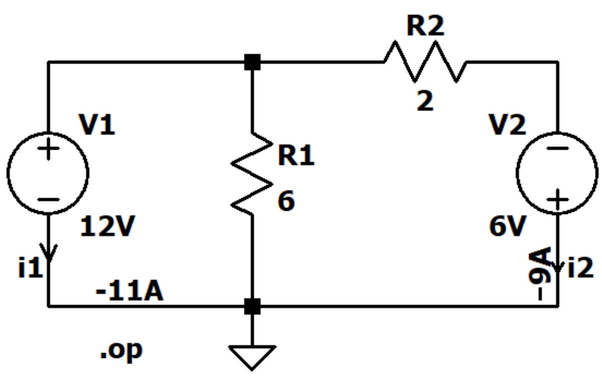

Figure 11: Circuit Schematic

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Simulated results are shown in Figure 12.
(i_2 is negative due to its direction.)

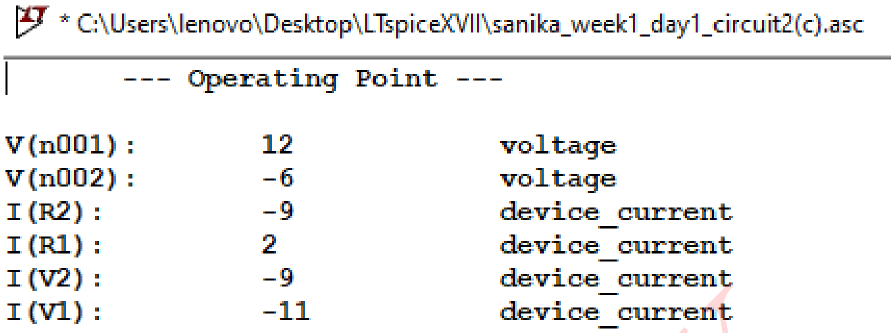

Figure 12: Simulated Results

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
i_1	-11A	-11A
i_2	9A	9A($\downarrow$)

Table 4: Numerical 4

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Numerical 5:

Find the current I and the power absorbed by each element in the circuit of Figure 13.

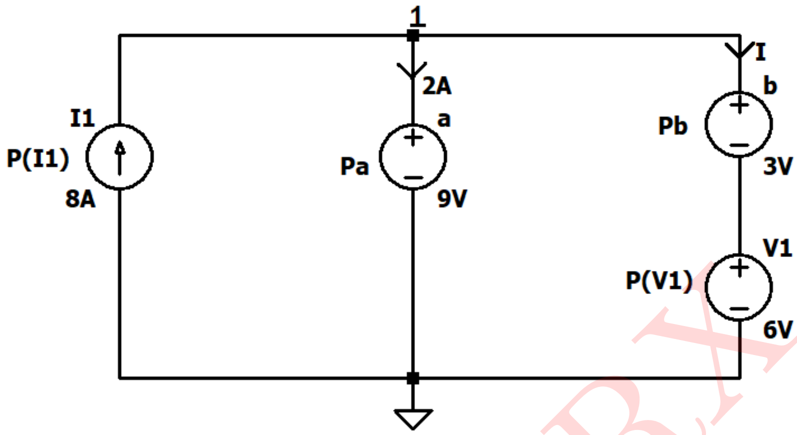

Figure 13: Circuit 5

Solution:

Applying KCL at node 1 in circuit 5,

I+2A = 8A

$\therefore$ I = 8−2

$\therefore$ **I = 6A**

$R_a = \dfrac{V_a}{I_a} = \dfrac{9}{2} = \mathbf{4.5\Omega}$

$R_b = \dfrac{V_b}{I_b} = \dfrac{3}{6} = \mathbf{0.5\Omega}$

$\therefore$ Power absorbed by each element,

$P_{I_1} = V_{I_1} \times I_1 = 9 \times -8 = \mathbf{-72W}$

$P_a = V_a \times I_a = 9 \times 2 = \mathbf{18W}$

$P_b = V_b \times I_b = 6 \times 3 = \mathbf{18W}$

$P_{V_1} = V_1 \times I_{V_1} = 6 \times 6 = \mathbf{36W}$

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SIMULATED RESULTS:

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

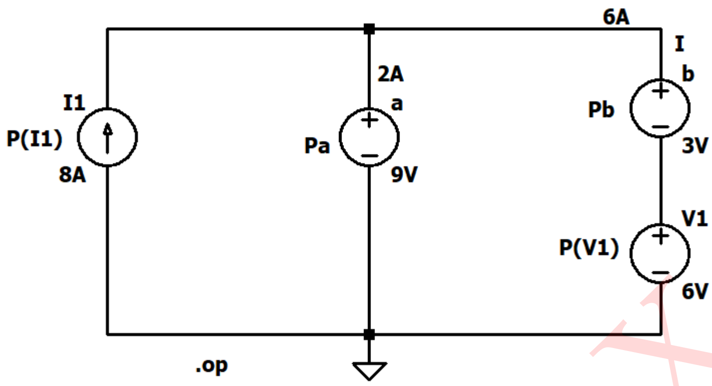

Figure 14: Circuit Schematic

Simulated results are shown in Figure 15.

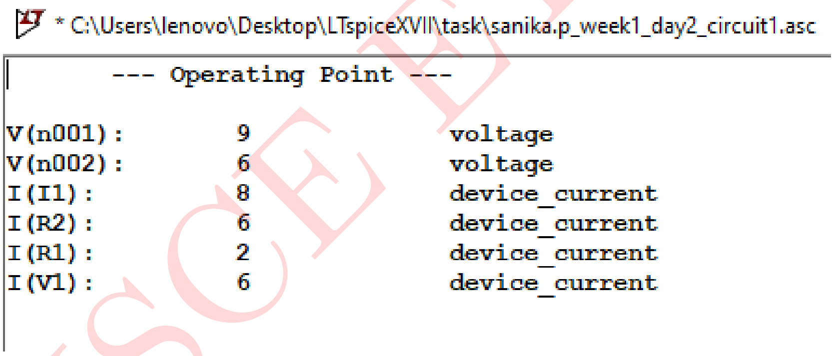

Figure 15: Simulated Results

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
I	6A	6A
P_{I_1}	-72W	-72W
P_a	18W	18W
P_b	18W	18W
P_{V_1}	36W	36W

Table 5: Numerical 5

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Numerical 6:

Find v (voltage across R_2) and i (current through R_3) in the circuit of Figure 16.

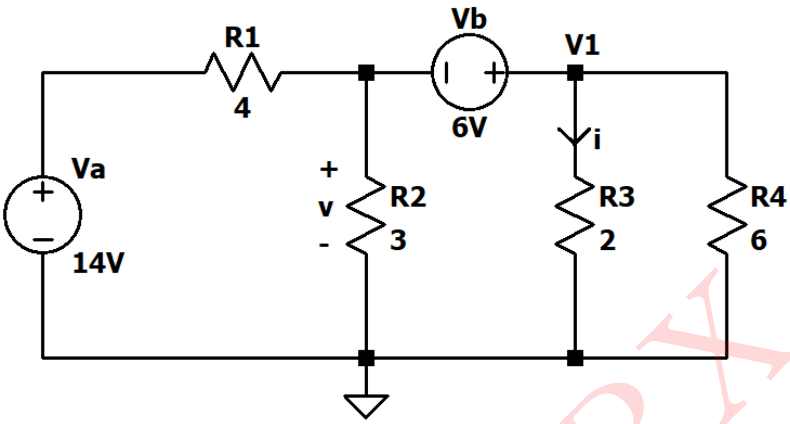

Figure 16: Circuit 6

Solution:

Using nodal analysis in the circuit 6,

$V_1 - v = 6V$ (Supernode) ...(1)

Applying KCL at supernode,

$$\frac{v-14}{4} + \frac{v}{3} + \frac{V_1}{2} + \frac{V_1}{6} = 0$$

$$\therefore \frac{v}{4} + \frac{v}{3} + \frac{V_1}{2} + \frac{V_1}{6} = 3.5$$

$$\frac{3v + 4v + 6V_1 + 2V_1}{12} = 3.5$$

$$7v + 8V_1 = 42$$

$$7v + 8 \times (6 + v) = 42$$ ...(from (1))

$$15v + 48 = 42$$

$$v = -\frac{6}{15}$$

$$\therefore v = \mathbf{-0.4V}$$

$$V_1 = 6 + v = 6 - 0.4$$

$$\therefore V_1 = 5.6V$$

$$i = \frac{V_1}{R_3} = \frac{5.6}{2}$$

$$\therefore i = \mathbf{2.8A}$$

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SIMULATED RESULTS:

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

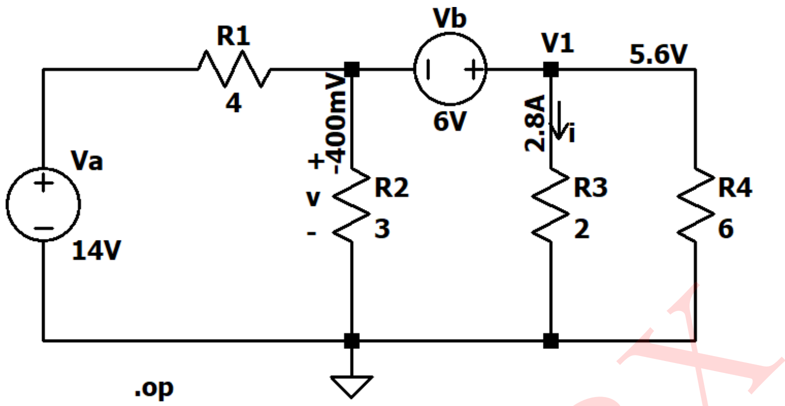
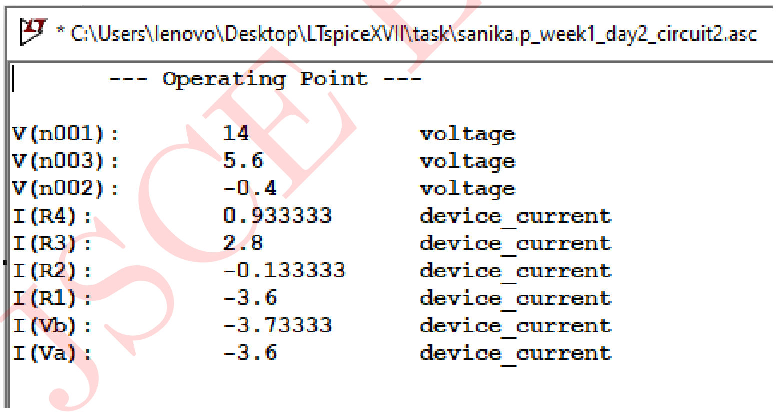


Figure 17: Circuit Schematic

Simulated results are shown in Figure 18.


* C:\Users\lenovo\Desktop\LTspiceXVII\task\sanika.p_week1_day2_circuit2.asc

```
        --- Operating Point ---

V(n001):        14              voltage
V(n003):        5.6             voltage
V(n002):        -0.4            voltage
I(R4):          0.933333        device_current
I(R3):          2.8             device_current
I(R2):          -0.133333       device_current
I(R1):          -3.6            device_current
I(Vb):          -3.73333        device_current
I(Va):          -3.6            device_current
```

Figure 18: Simulated Results

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
v_{R_2}	-0.4V	-0.4V
V_1	5.6V	5.6V
i_{R_3}	2.8A	2.8A

Table 6: Numerical 6

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Numerical 7:

Find the current I_{XY} flowing in the branch XY in the circuit of Figure 19 by superposition theorem.

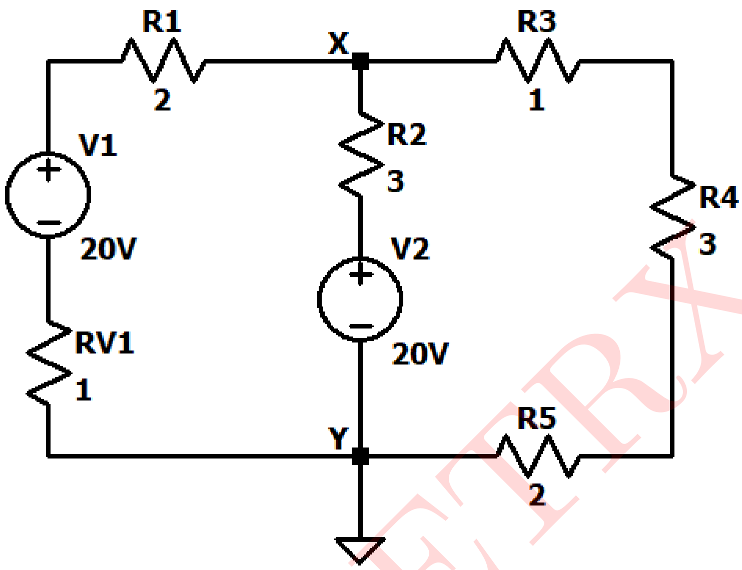

Figure 19: Circuit 7(a)

Solution:

In the circuit 7(a),

$R_O = R_3 + R_4 + R_5$

CASE 1: Only V_1 is active ...(Refer Figure 20)

In circuit 7(b),

$R_T = (R_{V_1} + R_1) + (R_2||R_O)$
$R_T = (1 + 2) + (3||6)$
$R_T = \mathbf{5\Omega}$

$$I_{V_1} = \frac{V_1}{R_T} = \frac{20}{5} = 4A$$

$$I_{R_2} = \frac{I_{V_1} \times R_O}{R_O + R_2} = \frac{4 \times 6}{6 + 3}$$

$\therefore I_{R_2} = 2.667A(\downarrow)$

$\therefore I_{(XY)_1} = \mathbf{2.667A}(\downarrow)$ ...(1)

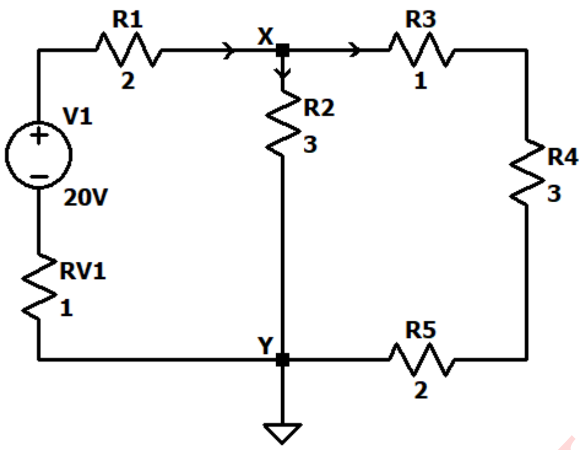

Figure 20: Circuit 7(b) - only V_1 is active

CASE 2: Only V_2 is active ...(Refer Figure 21)

In circuit 7(c),

$R_T = R_2 + (R_{V_1} + R_1||R_O)$

$R_T = 3 + (3||6)$

$R_T = \mathbf{5\Omega}$

$I_{V_2} = \frac{V_2}{R_T} = \frac{20}{5} = 4A$

$\therefore I_{(XY)_2} = \mathbf{4A}(\uparrow)$ ...(2)

$\therefore$ From (1) and (2),

$I_{XY} = 4 - 2.667$

$\therefore I_{XY} = \mathbf{1.33A}(\uparrow)$

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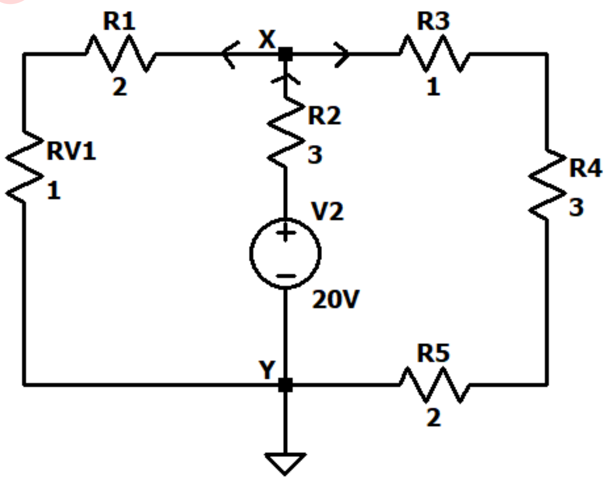


Figure 21: Circuit 7(c) - only V_2 is active

SIMULATED RESULTS:

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

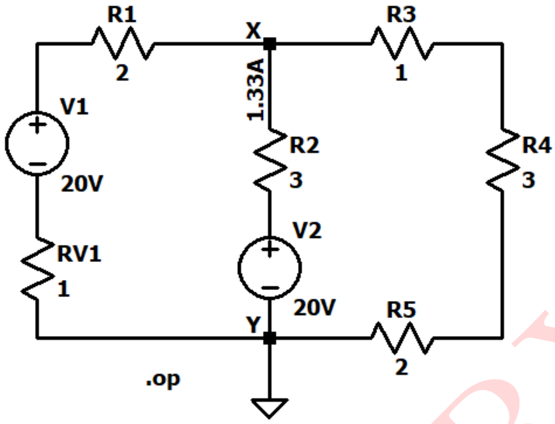
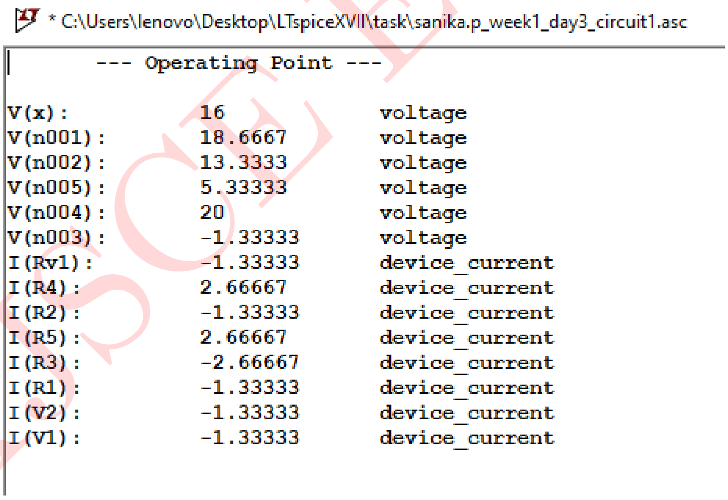


Figure 22: Circuit Schematic

Simulated results are shown in Figure 23.


* C:\Users\lenovo\Desktop\LTspiceXVII\task\sanika.p_week1_day3_circuit1.asc

```
       --- Operating Point ---

V(x):           16              voltage
V(n001):        18.6667         voltage
V(n002):        13.3333         voltage
V(n005):        5.33333         voltage
V(n004):        20              voltage
V(n003):        -1.33333        voltage
I(Rv1):         -1.33333        device_current
I(R4):          2.66667         device_current
I(R2):          -1.33333        device_current
I(R5):          2.66667         device_current
I(R3):          -2.66667        device_current
I(R1):          -1.33333        device_current
I(V2):          -1.33333        device_current
I(V1):          -1.33333        device_current
```

Figure 23: Simulated Results

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Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
$I_{(XY)_1}$	2.667A	2.667A
$I_{(XY)_2}$	4A	4A
I_{XY}	1.33A(↑)	1.33A (↑)

Table 7: Numerical 7

Numerical 8:

Find the Norton equivalent circuit in the Figure 24 at terminals a-b.

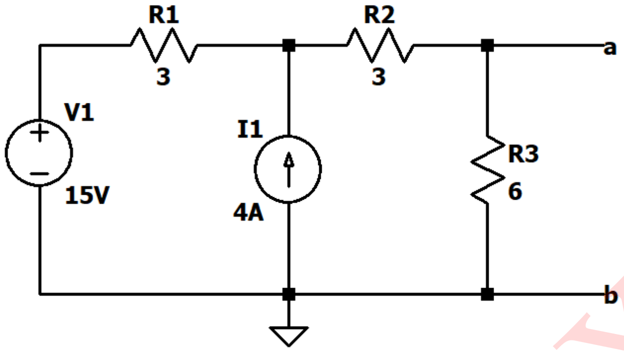

Figure 24: Circuit 8(a)

Solution:

1. For calculating R_N ...(Refer Figure 25)

$R_N = (R_1 + R_2)||R_3$

$R_N = (3 + 3)||6 = 6||6$

$R_N = \mathbf{3\Omega}$

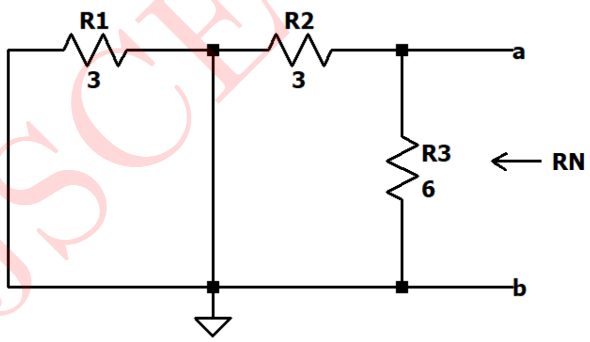

Figure 25: Circuit 8(b) - calculating R_N

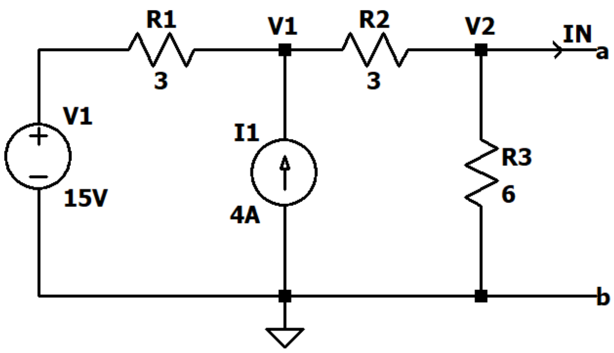

Figure 26: Circuit 8(c) - calculating I_N

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2. For calculating I_N ...(Refer Figure 26)

Using nodal analysis in the circuit 8(c),

For V_1,

$$\frac{V_1 - 15}{3} + \frac{V_1 - V_2}{3} = 4$$

$\therefore 2V_1 - V_2 = 27$ ...(1)

For V_2,

$$\frac{V_2 - V_1}{3} + \frac{V_2}{6} = 0$$

$\therefore 3V_2 = 2V_1$ ...(2)

Substituting (2) in (1),

$3V_2 - V_2 = 27$

$$\therefore V_2 = \frac{27}{2} = 13.5V$$

$$I_N = \frac{V_2}{R_N} = \frac{13.5}{3}$$

$\therefore I_N = \mathbf{4.5A}$

$\therefore$ Norton equivalent circuit is shown in Figure 27.

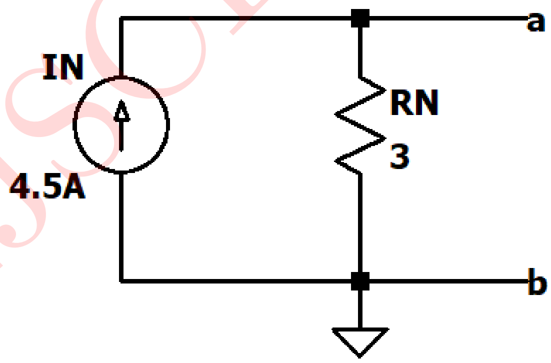

Figure 27: Norton equivalent circuit

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SIMULATED RESULTS:

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

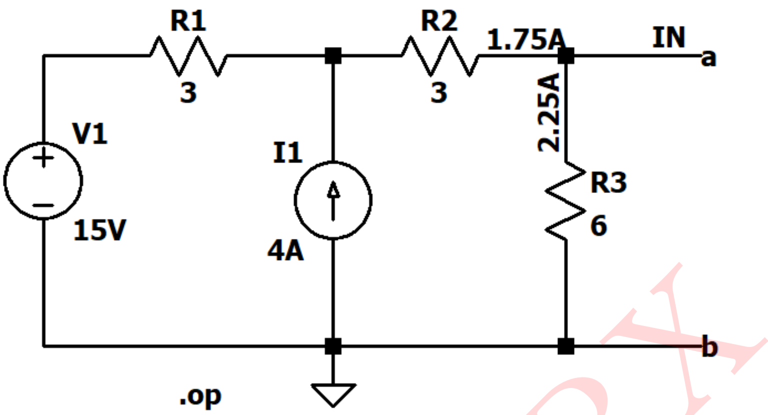

Figure 28: Circuit Schematic

Simulated results are shown in Figure 29.

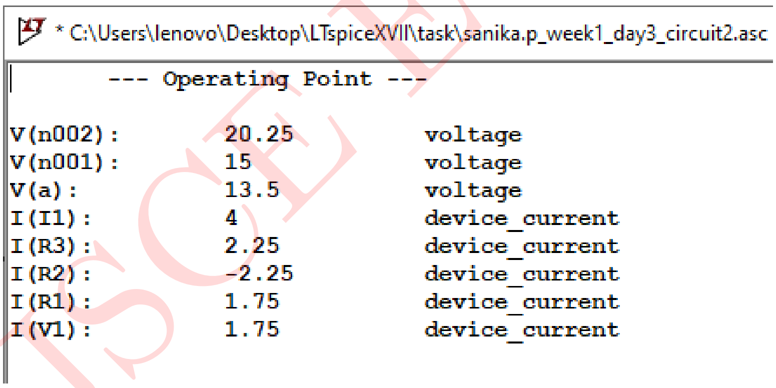

Figure 29: Simulated Results

$$(I_N = I_{R_1} + I_{R_3})$$

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
R_N	3Ω	3Ω
I_N	4.5A	4.5A

Table 8: Numerical 8

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Numerical 9:

For the circuit shown in Figure 30, calculate the current in 6Ω resistor by using Norton's Theorem.

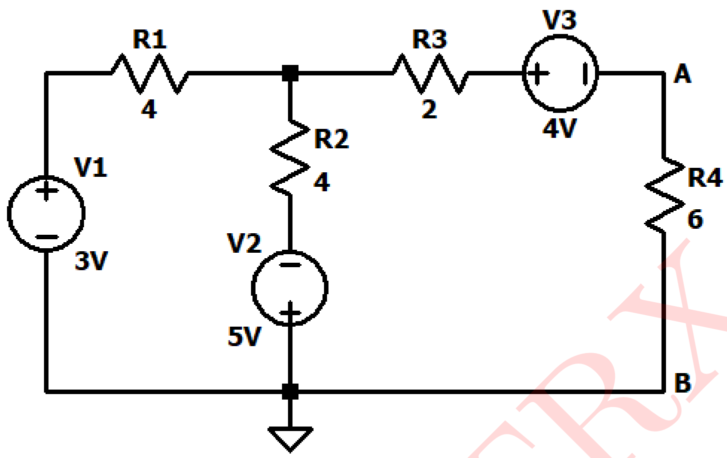

Figure 30: Circuit 9(a)

Solution:

1. Calculating I_N, ...(Refer Figure 31)

Using Mesh analysis,

For Mesh 1,

$3 - 4I_1 - 4(I_1 - I_2) + 5 = 0$

$-4I_1 - 4I_1 + 4I_2 + 8 = 0$

$8I_1 - 4I_2 = 8$

$\therefore 2I_1 - I_2 = 2$ ...(1)

For Mesh 2,

$-2I_2 - 4 - 5 - 4(I_2 - I_1) = 0$

$-2I_2 - 9 - 4I_2 + 4I_1 = 0$

$\therefore 4I_1 - 6I_2 = 9$ ...(2)

Solving (1) and (2) simultaneously,

$4I_2 = -5$

$\therefore I_2 = -1.25A$ $\quad I_1 = 0.375A$

From Figure 31, $I_2 = I_N$

$\therefore I_N = \mathbf{1.25A}(\uparrow)$ ...(direction of current is different from assumed)

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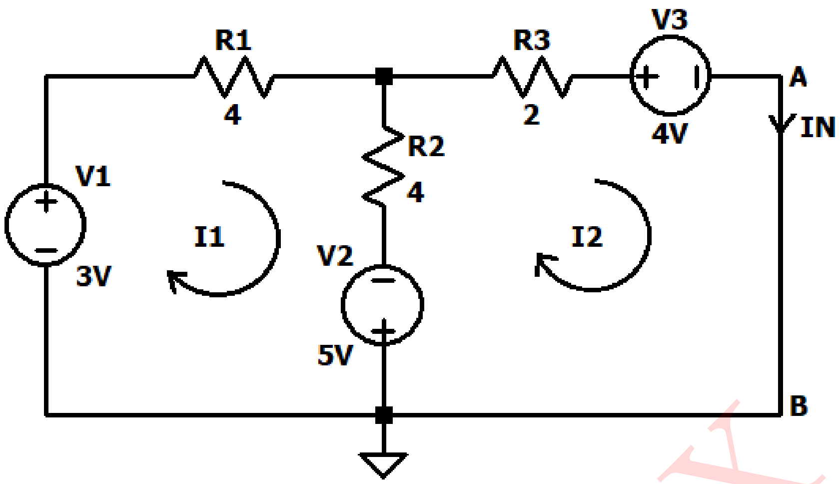

Figure 31: Circuit 9(b) - calculating I_N

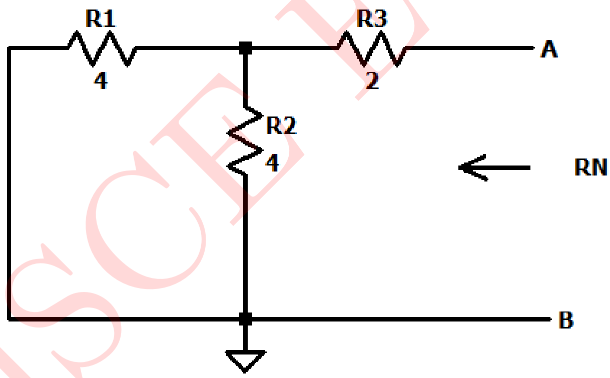

Figure 32: Circuit 9(c) - calculating R_N

2. Calculating R_N, ...(Refer Figure 32)

$R_N = (R_1||R_2) + R_3$

$R_N = (4||4) + 2 = 2 + 2$

$R_N = \mathbf{4}\Omega$

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∴ Norton equivalent circuit will be as shown in Figure 33.

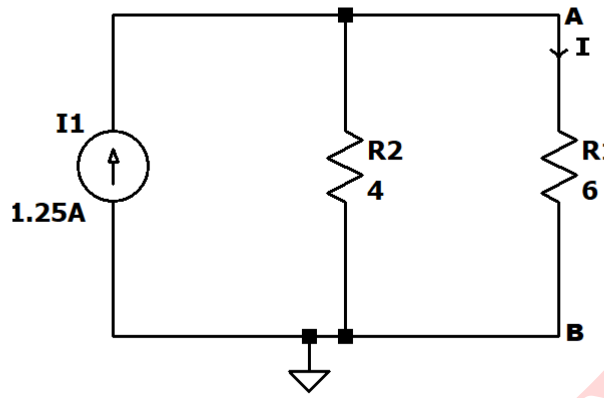

Figure 33: Norton equivalent circuit

∴ current in 6Ω resistor is,

$I = -\frac{5}{4} \times \frac{4}{10}$

I = $-$**0.5A**

SIMULATED RESULTS:

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

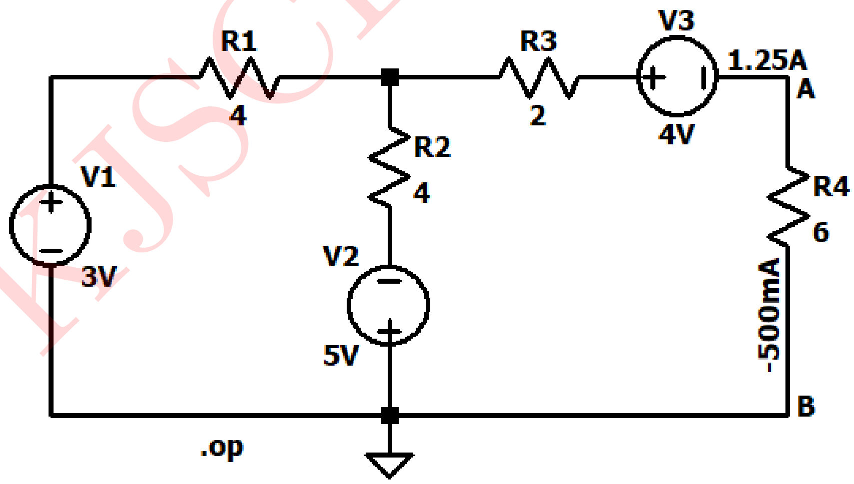

Figure 34: Circuit Schematic

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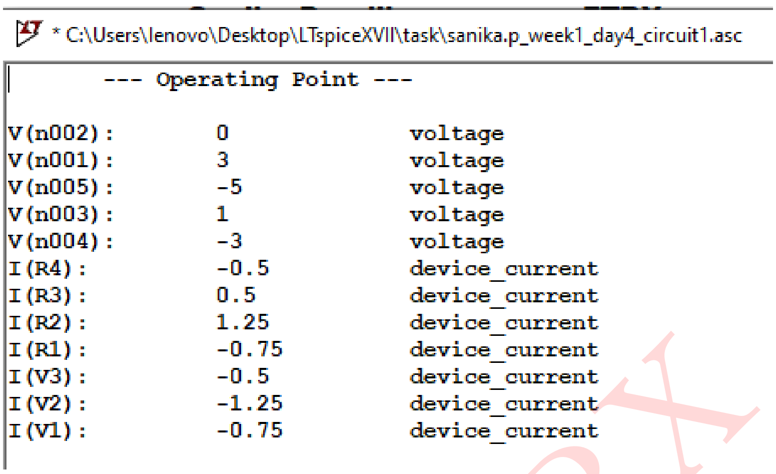
Simulated results are shown in Figure 35.



```
* C:\Users\lenovo\Desktop\LTspiceXVII\task\sanika.p_week1_day4_circuit1.asc
       --- Operating Point ---

V(n002):        0              voltage
V(n001):        3              voltage
V(n005):        -5             voltage
V(n003):        1              voltage
V(n004):        -3             voltage
I(R4):          -0.5           device_current
I(R3):          0.5            device_current
I(R2):          1.25           device_current
I(R1):          -0.75          device_current
I(V3):          -0.5           device_current
I(V2):          -1.25          device_current
I(V1):          -0.75          device_current
```

Figure 35: Simulated Results

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
I_N	1.25A(↑)	1.25A(↑)
I	-0.5A	-0.5A
I_1	0.375A	0.375A

Table 9: Numerical 9

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Numerical 10:

Find the value of current flowing through 6Ω resistor using Thevenin Theorem.

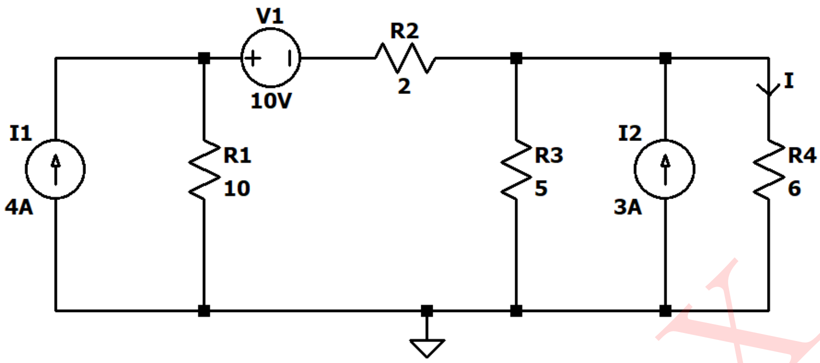

Figure 36: Circuit 10(a)

Solution:

Using source transformation, the circuit can be drawn as :

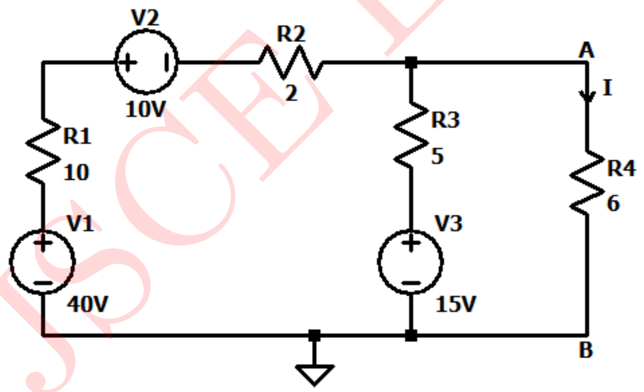

Figure 37: Circuit 10(b)

1. Calculating V_{th} ..(Refer Figure 38)

Using Mesh analysis,

$40 - 10I_1 - 10 - 2I_1 - 5 - 15I_1 = 0$

$27I_1 = 25$

$\therefore I_1 = \dfrac{25}{27} = 0.9259A$

writing V_{th} equation,

$-V_{th} + 5I_1 + 15 = 0$

$V_{th} = (5 \times 0.9259) + 15$

$\therefore V_{th} = \mathbf{19.629V}$

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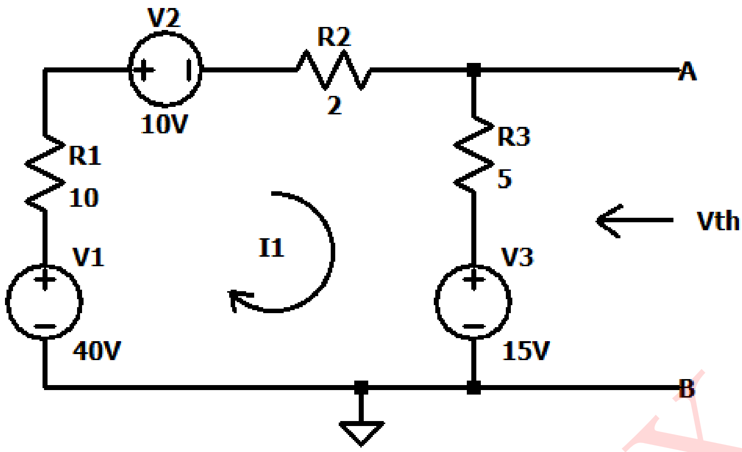

Figure 38: Circuit 10(c) - calculating V_{th}

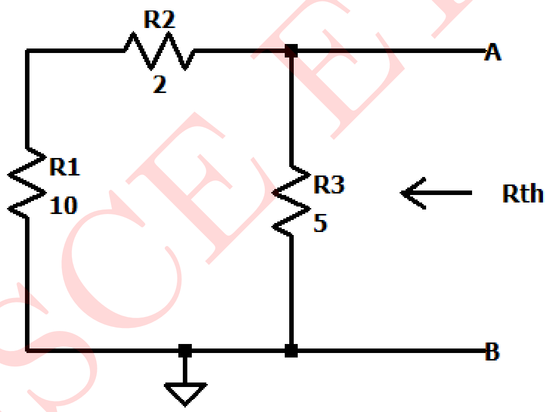

Figure 39: Circuit 10(d) - calculating R_{th}

2. Calculating R_{th}, ...(Refer Figure 39)

$R_{th} = (R_1 + R_2)||R_3$

$R_{th} = (10 + 2)||5$

$R_{th} = 12||5 = \frac{60}{17}$

$\therefore R_{th} = \mathbf{3.5294\Omega}$

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∴ Thevenin equivalent circuit will be as shown in Figure 40.

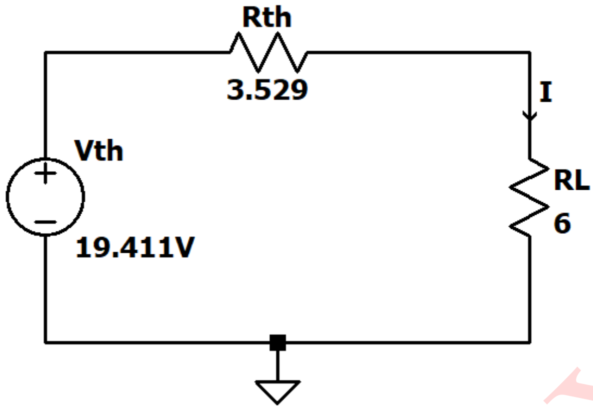

Figure 40: Thevenin equivalent circuit

$$I = \frac{V_{th}}{R_{th} + R_L} = \frac{19.629}{3.5294 + 6}$$

$\therefore I = \mathbf{2.059A}$

SIMULATED RESULTS:

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

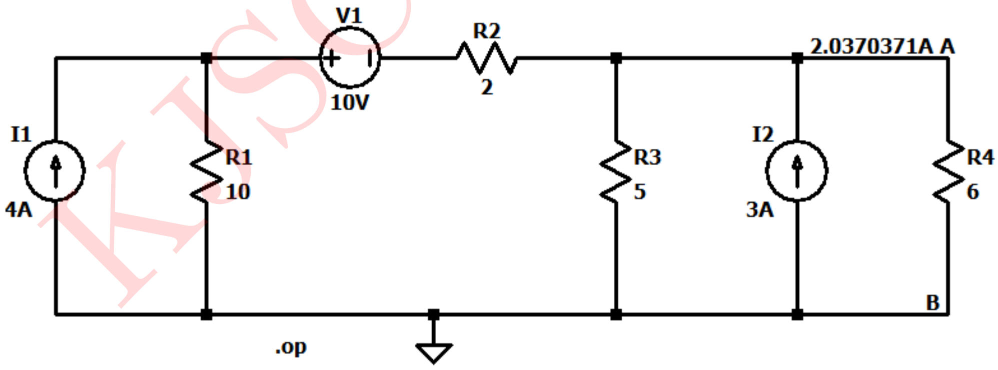

Figure 41: Circuit Schematic

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Simulated results are shown in Figure 42.

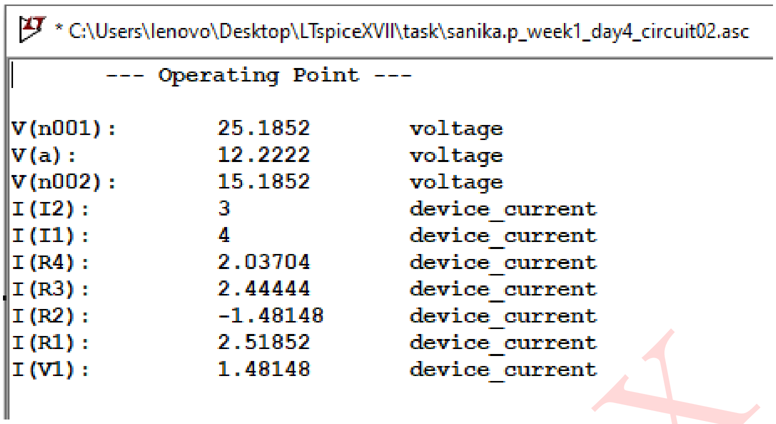

Figure 42: Simulated Results

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
V_{th}	19.629V	19.411V
I	2.059A	2.037A

Table 10: Numerical 10

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Numerical 11:

For the circuit given in Figure 43, what will be the R_L to get the maximum power? What is the maximum power delivered to the load?

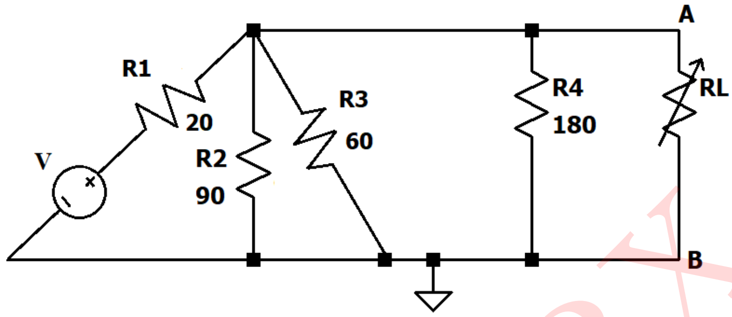

Figure 43: Circuit 11(a)

Solution:

The circuit given in Figure 43 can also be drawn as shown in Figure 44.

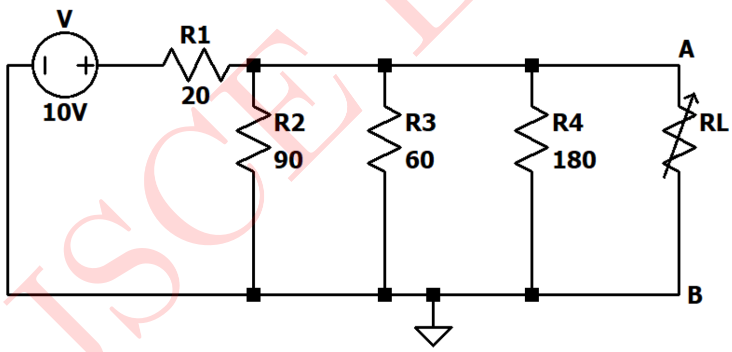

Figure 44: Simplified Circuit

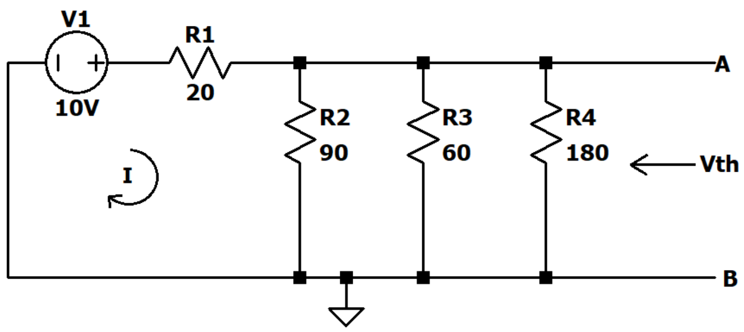

Figure 45: Circuit 11(b) - For calculating V_{th}

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1. Calculating V_{th}:

Applying Mesh analysis in Figure 45.

$10 - 20I - 30I = 0$

$50I = 10$

$\therefore I = 0.2A$

Writing V_{th} equation,

$-V_{th} + 30I = 0$

$V_{th} = 30I$

$V_{th} = 30 \times 0.2$

$\therefore V_{th} = \mathbf{6V}$

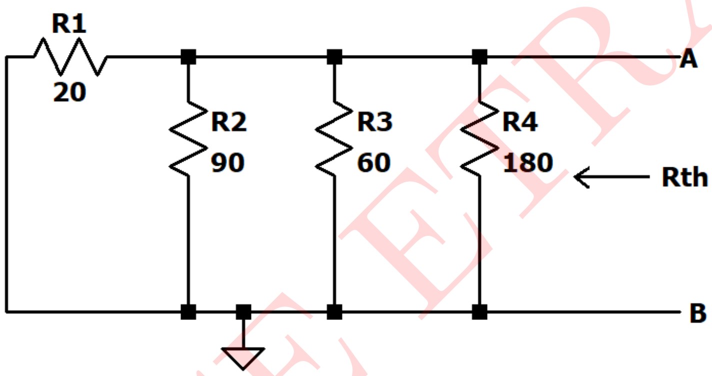

Figure 46: Circuit 11(c) - For calculating R_{th}

2. Calculating R_{th}:

$R_{th} = R_1 \,||\, R_2 \,||\, R_3 \,||\, R_4$

$R_{th} = 20 \,||\, 90 \,||\, 60 \,||\, 180$

$\therefore R_{th} = \mathbf{12\Omega}$

For Maximum Power Transfer,

$R_L = R_{th}$

$\therefore R_L = \mathbf{12\Omega}$

$$P_{max} = \frac{V_{th}^2}{4R_{th}} = \frac{6^2}{4 \times 12} = \frac{36}{48}$$

$\therefore P_{max} = \mathbf{0.75W}$

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SIMULATED RESULTS:

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

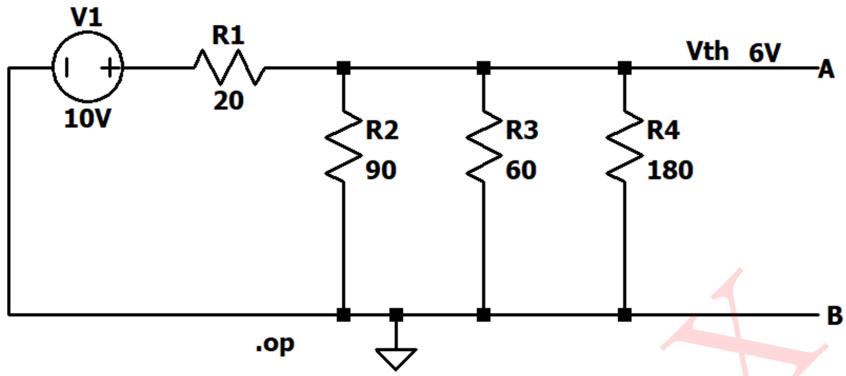

Figure 47: Circuit Schematic

Simulated results are shown in Figure 48.

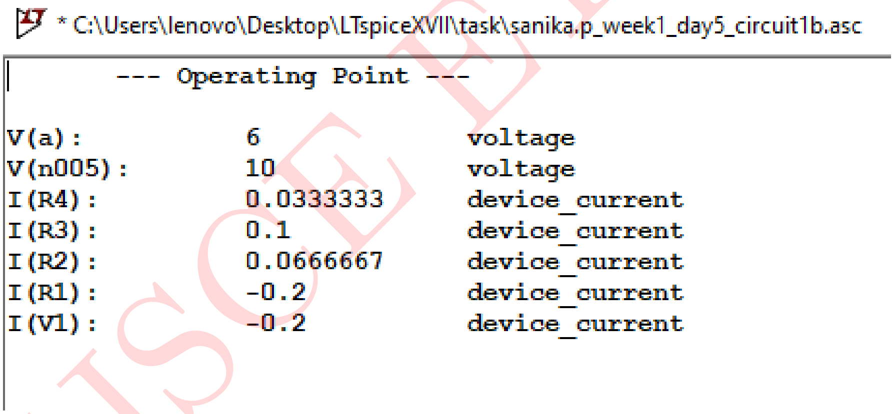

Figure 48: Simulated Results

For the circuit in Figure 47,

$$P_{max} = \frac{V_a^2}{4R_{th}} = \frac{6^2}{4 \times 12} = \frac{36}{48}$$

$\therefore P_{max} = \mathbf{0.75W}$

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
P_{max}	0.75W	0.75W
V_{th}	6V	6V
I	0.2A	0.2A

Table 11: Numerical 11

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