CSE 231
- Homework 2 -
20.11.2020

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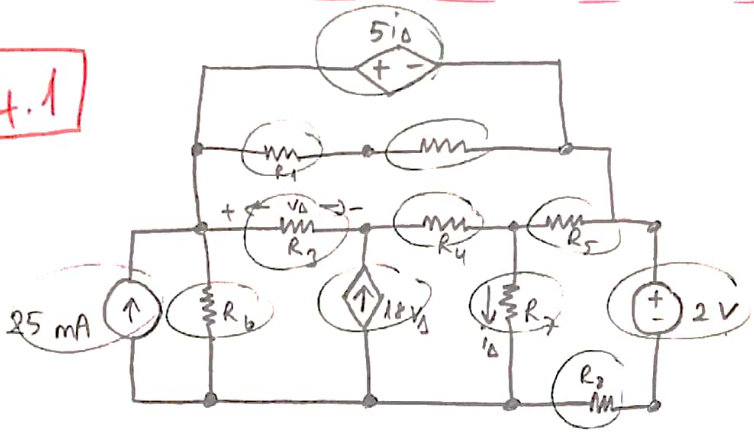
4.1



a) Branches → 12 branches

b) Branches where the current is unknown → Every branch except 25 mA branch.

c) Essential branches → 10 essential branches.

d) Essential branches where the current is unknown → 9 essential branches.

e) Nodes → 7 nodes

f) Essential nodes → 5 essential nodes

g) Meshes → 6 meshes

4.2

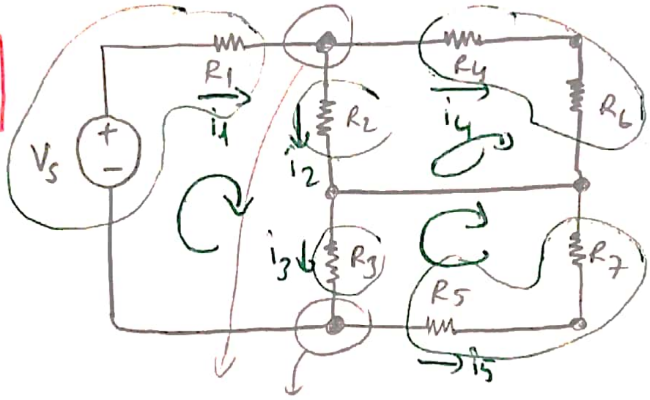
a) Essential branches where the current is unknown → There are 9 so we need 9 equations.

b) We can apply KCL → 4 essential nodes.

c) 4 equations must be derived using KVL.

d) We should avoid where the current source occurs. At the bottom, there are two meshes contains a current source. We cannot determine the voltage across that current source.

4.3



a) There are 8 circuit components. But R_4-R_6, R_5-R_7, and V_s-R_1 are series. So we have 8-3=5 unknown currents.

b) There are two independent KCL equations.

c) $i_1 = i_2 + i_4$, $i_3 = i_1 + i_5$

d) There are 3 meshes. So we can write three independent KVL equations.

e) $-V_s + R_1 i_1 + R_2 i_2 + R_3 i_3 = 0$

$R_4 i_4 + R_6 i_4 - R_2 i_2 = 0$

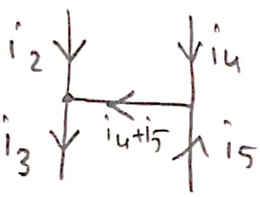
$R_3 i_3 + R_5 i_5 + R_7 i_5 = 0$

4.4

a) 1. $i_2 + i_4 - i_1 = 0$

2. $i_1 + i_5 - i_3 = 0$

3. $i_2 + i_4 + i_5 - i_3 = 0$

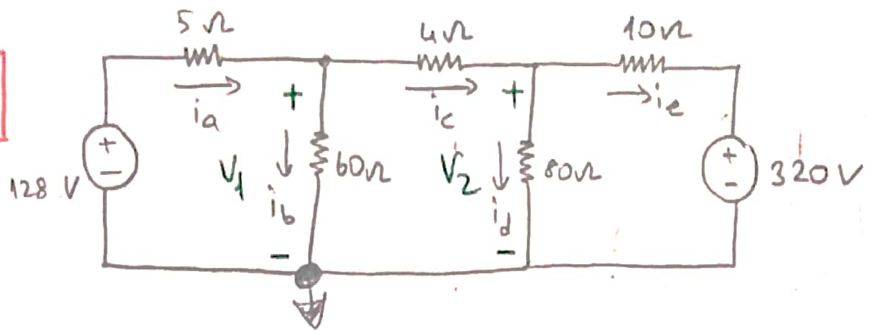


b) If we add 1. and 2. equations

$$(i_2 + i_4 - i_1) + (i_1 + i_5 - i_3) = i_2 + i_4 + i_5 - i_3$$

We can reach 3. equation.

4.11



a) $$\frac{V_1-128}{5}+\frac{V_1}{60}+\frac{V_1-V_2}{4}=0 \longrightarrow \frac{12V_1-128\cdot 12+V_1+15V_1-15V_2}{60}=0$$

$$\frac{V_2-V_1}{4}+\frac{V_2}{80}+\frac{V_2-320}{10}=0 \longrightarrow \frac{20V_2-20V_1+V_2+8V_2-320\cdot 8}{80}=0$$

Result → $V_1 = 162\ V$

$V_2 = 200\ V$

$$i_a=\frac{128-V_1}{5}=\underline{\underline{-6.8\ A}}$$

$$i_c=\frac{V_1-V_2}{4}=\underline{\underline{-9.5\ A}}$$

$$i_b=\frac{V_1}{60}=\underline{\underline{2.7\ A}}$$

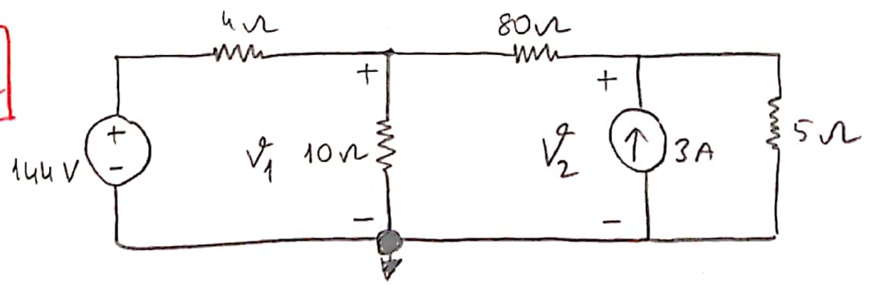
$$i_e=\frac{V_2-320}{10}=\underline{\underline{-12\ A}}$$

$$i_d=\frac{V_2}{80}=\underline{\underline{2.5\ A}}$$

b) $$\boxed{P=V\cdot I=\frac{V^2}{R}=I^2\cdot R}$$

$$P_{320V}=320\cdot i_e=320\cdot(-12)=\underline{\underline{-3840\ W}}$$

4.12



$V_1 = ?$

$V_2 = ?$

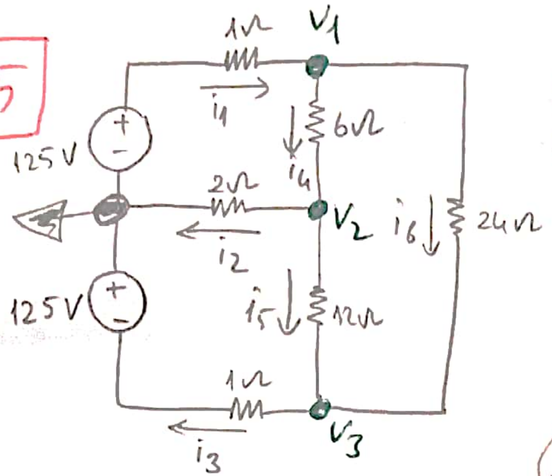
$$\frac{V_1-144}{4}+\frac{V_1}{10}+\frac{V_1-V_2}{80}=0 \longrightarrow \frac{20V_1-144\cdot 20+8V_1+V_1-V_2}{80}=0$$

$$-3+\frac{V_2-V_1}{80}+\frac{V_2}{5}=0 \longrightarrow \frac{80\cdot(-3)+V_2-V_1+16V_2}{80}=0$$

Result → $V_1 = 100\ V$

$V_2 = 20\ V$ //

4.15



a)

$$\boxed{\frac{v_1-125}{1}+\frac{v_1-v_2}{6}+\frac{v_1-v_3}{24}=0}$$

$$\boxed{\frac{v_2-v_1}{6}+\frac{v_2}{2}+\frac{v_2-v_3}{12}=0}$$

$$\boxed{\frac{v_3+125}{1}+\frac{v_3-v_2}{12}+\frac{v_3-v_1}{24}=0}$$

$$24v_1-125\cdot 24+4v_1-4v_2+v_1-v_3=0$$

$$2v_2-2v_1+6v_2+v_2-v_3=0$$

$$24v_3+125\cdot 24+2\cdot v_3-2v_2+v_3-v_1=0$$

$$\underline{\underline{v_1=101.24\text{ V}}}\qquad \underline{\underline{v_2=10.66\text{ V}}}\qquad \underline{\underline{v_3=-106.57}}$$

$$i_1=\frac{125-v_1}{1}=\underline{\underline{23.76\text{ A}}}$$

$$i_2=\frac{v_2}{2}=\underline{\underline{5.33\text{ A}}}$$

$$i_3=\frac{v_3+125}{1}=\underline{\underline{18.43\text{ A}}}$$

$$i_4=\frac{v_1-v_2}{6}=\underline{\underline{15.10\text{ A}}}$$

$$i_5=\frac{v_2-v_3}{12}=\underline{\underline{9.77\text{ A}}}$$

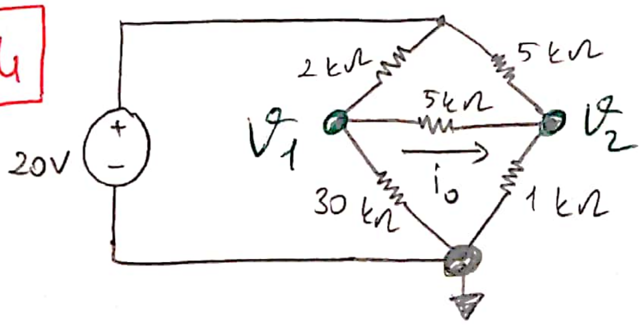
$$i_6=\frac{v_1-v_3}{24}=\underline{\underline{8.66\text{ A}}}$$

b) $P_{developed}=125i_1+125i_3=125\cdot(23.76)+125\cdot(18.43)=\underline{\underline{5273.09\text{ W}}}$

$P_{dissipated}=i_1^2\cdot 1+i_4^2\cdot 6+i_2^2\cdot 2+i_5^2\cdot 12+i_3^2\cdot 1+i_6^2\cdot 24=\underline{\underline{5273.09\text{ W}}}$

same

4.24



$$\boxed{\frac{v_1}{30k}+\frac{v_1-v_2}{5k}+\frac{v_1-20}{2k}=0}$$

$$\boxed{\frac{v_2}{1k}+\frac{v_2-v_1}{5k}+\frac{v_2-20}{5k}=0}$$

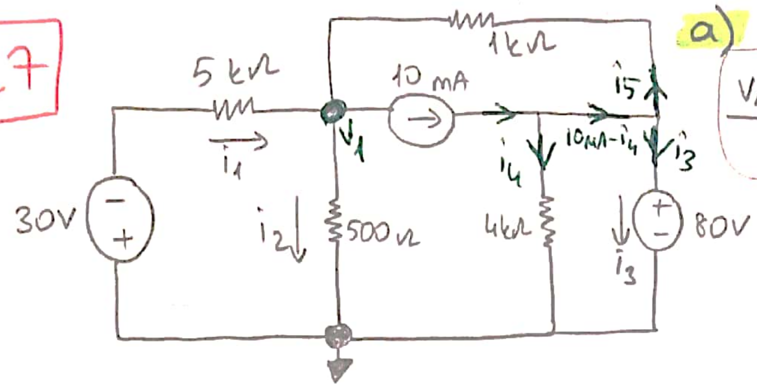
$$\boxed{\begin{aligned}&v_1+6v_1-6v_2+15v_1-20\cdot 15=0\\&5v_2+v_2-v_1+v_2-20=0\end{aligned}}$$

$$v_1=15\text{V}\qquad v_2=5\text{V}$$

$$i_0=\frac{v_1-v_2}{5k}=\frac{15-5}{5000}$$

$$=\underline{\underline{0.002\text{ A}}}$$

4.27



a)

$$\frac{V_1+30}{5k} + \frac{v_1}{500} + \frac{v_1-80}{1k} + \frac{0.01}{1} = 0$$

$$V_1 + 30 + 10V_1 + 5V_1 - 80.5 + 50 = 0$$

$$v_1 = 20\ V$$

$$i_4 = \frac{80}{4k} = 20\ mA \qquad i_5 = \frac{80-v_1}{1k} = 60\ mA \qquad i_1 = \frac{-30-v_1}{5k} = \underline{\underline{-10\ mA}} = \underline{\underline{-0.01\ A}}$$

$$10\ mA - i_4 = i_5 + i_3 \qquad i_2 = \frac{v_1}{500} = \underline{\underline{40\ mA}} = \underline{\underline{0.04A}}$$

$$10\ mA - i_4 - i_5 = i_3$$

$$10\ mA - 20_{mA} - 60_{mA} = i_3 = \underline{\underline{-70\ mA}} = \underline{\underline{-0.07\ A}}$$

b)

$$P_{30V} = V \cdot I = 30 \cdot (-0.01) = -0.3\ W$$

$$P_{5k} = I^2 \cdot R = (0.01)^2 \cdot 5k = 0.5\ W$$

$$P_{500\Omega} = I^2 \cdot R = (0.04)^2 \cdot 500 = 0.8\ W$$

$$P_{10mA} = V \cdot I = (v_1 - 80) \cdot (0.01) = -0.6\ W$$

$$P_{4k} = I^2 \cdot R = (0.02)^2 \cdot (4000) = 1.6\ W$$

$$P_{80V} = V \cdot I = 80 \cdot (-0.07) = -5.6\ W$$

$$P_{1k} = I^2 \cdot R = (0.06)^2 \cdot (1000) = 3.6\ W$$

dissipated

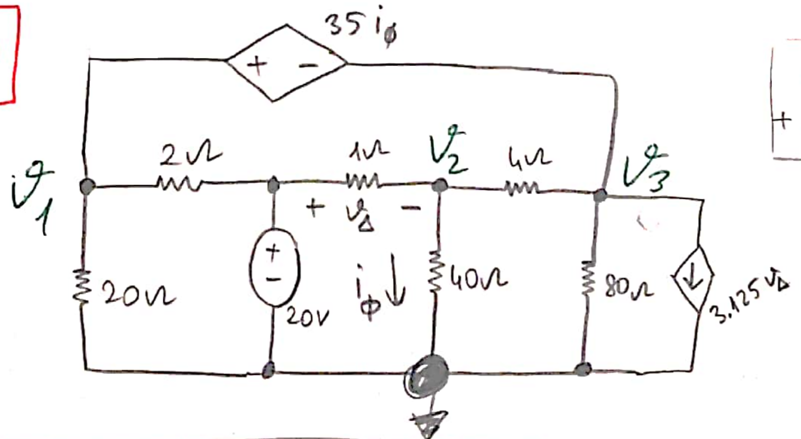
$$-0.3 - 0.6 - 5.6 = -6.5\ W$$

$$\|$$

$$0.5 + 0.8 + 1.6 + 3.6 = 6.5\ W$$

developed

4.30



$$\frac{v_1}{20} + \frac{v_1 - 20}{2} + \frac{v_3 - v_2}{4} + \frac{v_3}{80} + 3.125 v_\Delta = 0$$

$$\frac{v_2}{40} + \frac{v_2 - v_3}{4} + \frac{v_2 - 20}{1} = 0$$

$$4v_1 + 40v_1 - 20 \cdot 40 + 20v_3 + 20 \cdot (-v_2) + v_3 + 3.125 v_\Delta \cdot 80 = 0$$

$$v_2 + 10v_2 - 10v_3 + 40v_2 - 800 = 0$$

$$v_\Delta = \frac{20 - v_2}{1} \qquad \frac{v_2}{40} = i_\phi \qquad v_1 - v_3 = 35 i_\phi$$

$$v_1 = -20.25V$$

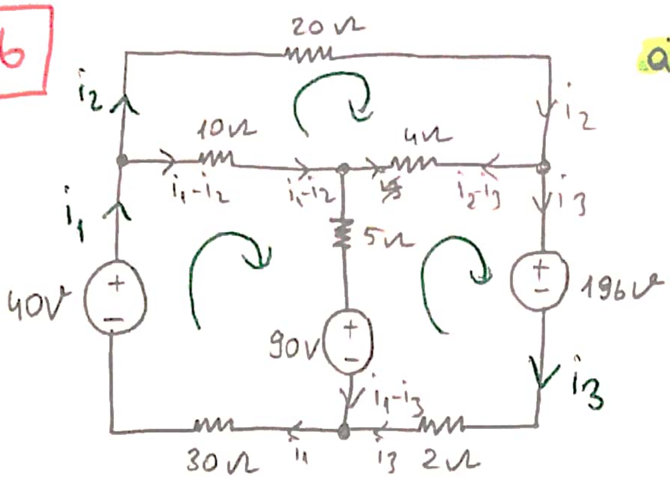
$$v_2 = 10\ V$$

$$V_3 = -29V$$

$$P_{developed_{20V}} = V \cdot I = 20 \cdot \left(\frac{20 - v_1}{2} + \frac{20 - v_2}{1}\right)$$

$$= 20 \cdot (30.125) = 602.5\ W$$

4.36



a) $40+10(i_1-i_2)+5(i_1-i_3)+90+30i_1=0$

$20i_2+4(i_2-i_3)+10(i_2-i_1)=0$

$196+2i_3-90+5(i_3-i_1)+4(i_3-i_2)=0$

$i_1=-5A \quad i_2=-3A$

$i_3=-13A$

$P_{40V}=V.I=40\cdot(-5)=-200\,W$

$P_{196V}=V.I=196\cdot(-13)=-2548\,W$

$P_{developed}=\underline{\underline{-2748\,W}}$

$=$

b) $P_{20\Omega}=I^2.R=(-3)^2\cdot 20=180\,W$

$P_{10\Omega}=I^2R=(-5+3)^2\cdot 10=40\,W$

$P_{4\Omega}=I^2R=(-3+13)^2\cdot 4=400\,W$

$P_{5\Omega}=I^2R=(-5+13)^2\cdot 5=320\,W$

$P_{30\Omega}=I^2R=(-5)^2\cdot 30=750\,W$

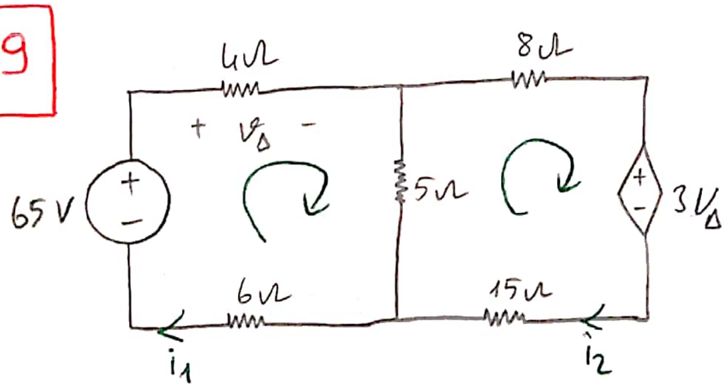
$P_{2\Omega}=I^2R=(-13)^2\cdot 2=338\,W$

$P_{90V}=V\cdot I=90(-5+13)=720\,W$

$+$

$P_{dissipated}=\underline{\underline{2748\,W}}$

4.39



$-65+4i_1+5(i_1-i_2)+6i_1=0$

$8i_2+3V_\Delta+15i_2+5(i_2-i_1)=0$

$\Rightarrow i_1=4A,\ i_2=-1A,\ V_\Delta=16V$

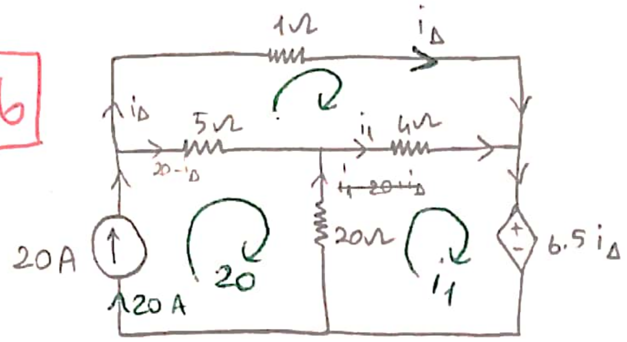
$V=I\cdot R$

$V_\Delta=i_1\cdot 4$

$P_{15\Omega}=I^2.R=(-1)^2\cdot 15$

$=\underline{\underline{15\,W}}$

4.46



$$24 i_1 + 6.5 i_\Delta - 4 i_\Delta - 20 \cdot 20 = 0$$

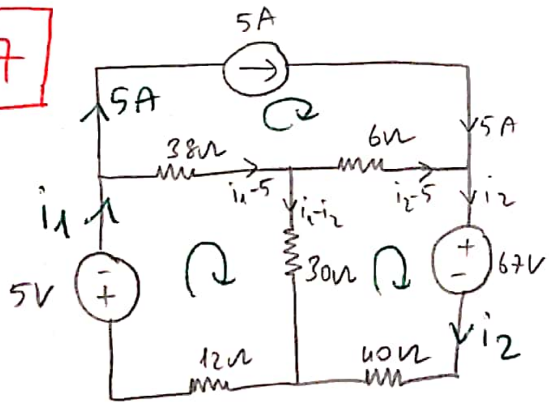
$$(5+4+1)\, i_\Delta - 4 i_1 - 5 \cdot 20 = 0$$

$i_1 = 15\,A \qquad i_\Delta = 16\,A$

$$P_{20A} = I \cdot V = 20 \cdot (7.5 \cdot 16)$$

$$= 2400\ W$$

4.47



a) $5 + 38 \cdot (i_1 - 5) + 30 \cdot (i_1 - i_2) + 12 i_1 = 0$

$67 + 40 i_2 + 30 (i_2 - i_1) + 6 (i_2 - 5) = 0$

$i_1 = 2.5\,A \qquad i_2 = 0.5\,A$

$$P_{5A} = I \cdot V = 5 \cdot \left(38 \cdot (i_1 - 5) + 6 \cdot (i_2 - 5)\right)$$

$$P_{5A} = 5 \cdot (-122) = -610\ W$$

b) $P_{5V} = V \cdot I = 5 \cdot i_1 = 5 \cdot (2.5) = 12.5\ W$

$P_{67V} = V \cdot I = 67 \cdot i_2 = 67 \cdot (0.5) = 33.5\ W$

They are all positive. So $P_{delivered} = P_{5A} = -610\ W$

$=$

c) $P_{38\Omega} = I^2 R = (i_1 - 5)^2 \cdot 38$

$P_{6\Omega} = I^2 R = (i_2 - 5)^2 \cdot 6$

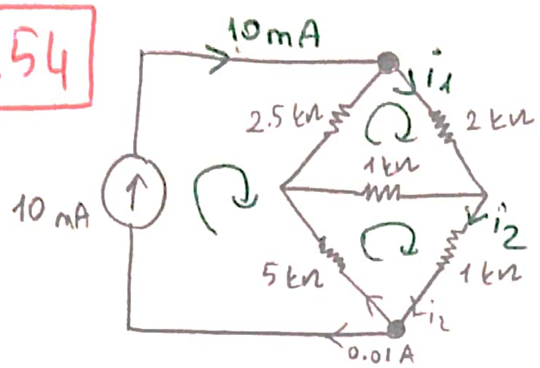
$P_{30\Omega} = I^2 R = (i_1 - i_2)^2 \cdot 30$

$P_{12\Omega} = I^2 R = i_1^2 \cdot 12$

$P_{40\Omega} = I^2 R = i_2^2 \cdot 40$

$+\ 46 = 610\ W = P_{dissipated}$

4.54



a) There are three meshes and one of the mesh has known current. So we should use mesh analysis.

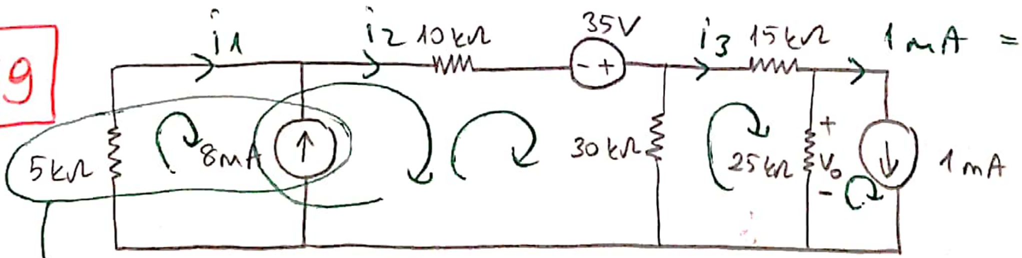
b) $2.5k\cdot(i_1-0.01)+2\cdot k(i_1)+1\cdot(i_1-i_2)=0$
$5k\,(i_2-0.01)+1k\,(i_2-i_1)+1ki_2=0$ → $i_1=0.006\ A$, $i_2=0.008\ A$

Horizontal ← $P_{1k\Omega}=I^2\cdot R=(i_1-i_2)\cdot R=(0.006-0.008)^2\cdot 1000=-0.004\ W$

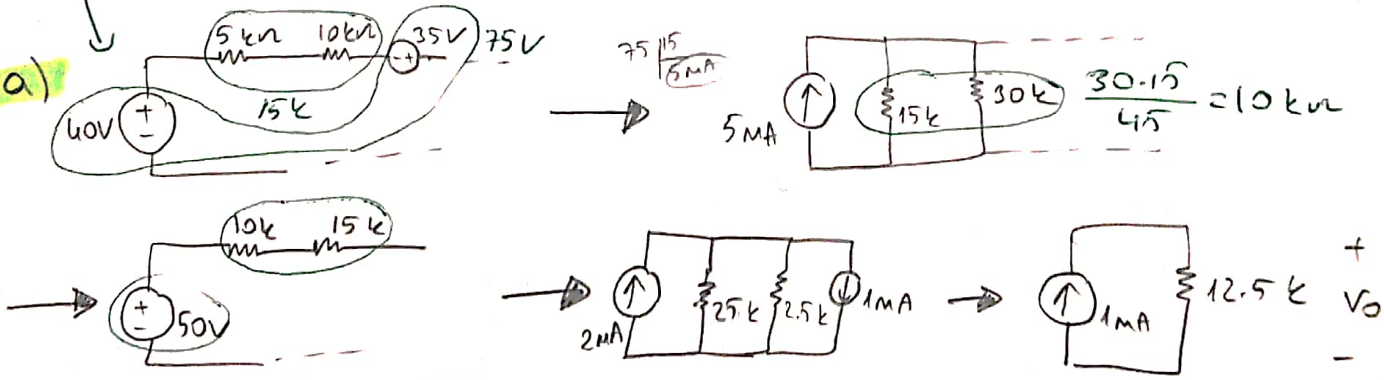
c) No. Because mesh analysis is easy method to find current. I choose this method again

d) $P_{delivered_{10mA}}=I\cdot V=(0.01)\cdot(2k\cdot i_1+1k i_2)$
$=(0.01)\cdot(2000\cdot(0.006)+1000\cdot(0.008))$
$=0.2\ W$

4.59



a)

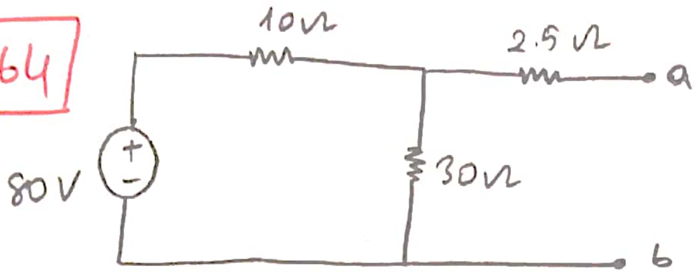


b) $5ki_1+(30k+10k)i_2-30ki_3-35=0$
$0.008+i_1=i_2$
$30k(i_3-i_2)+15ki_3+25k\cdot(i_3-0.001)=0$
$i_1=-5.33\ mA$ $i_2=2.67\ mA$ $i_3=1.5\ mA$

$V=1\cdot R$
$V_0=(0.001)\cdot(12500)$
$V_0=12.5\ V$

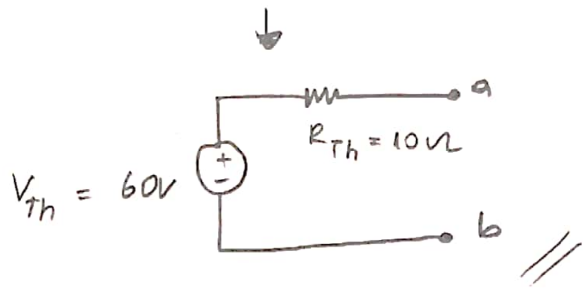
$V_0=1\cdot R=(1.5-0.001)\cdot 25k$
$=12.5\ V$

4.64

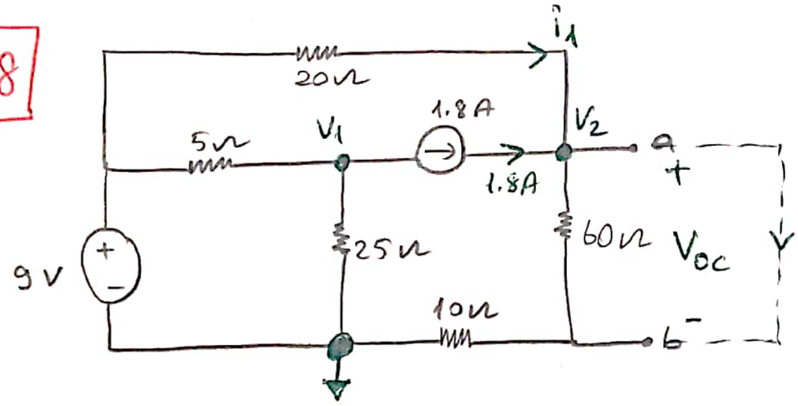


$$V_{Th} = \frac{30}{40} \cdot 80 = \underline{\underline{60\,V}}$$

$$R_{TH} = 2.5 + \frac{10 \cdot 30}{10+30} = \underline{\underline{10\,\Omega}}$$



4.78



a)

V_{oc}

$$\frac{V_2-9}{20} + \frac{V_2}{70} - 1.8 = 0$$

$$V_2 = 35\,V$$

$$V_{Th} = \frac{60}{60+10} \cdot 35 = \underline{\underline{30\,V}}$$

$$V_{Th} = V_{oc}$$

i_{sc}

$$\frac{V_2 - 9}{20} + \frac{V_2}{10} - 1.8 = 0$$

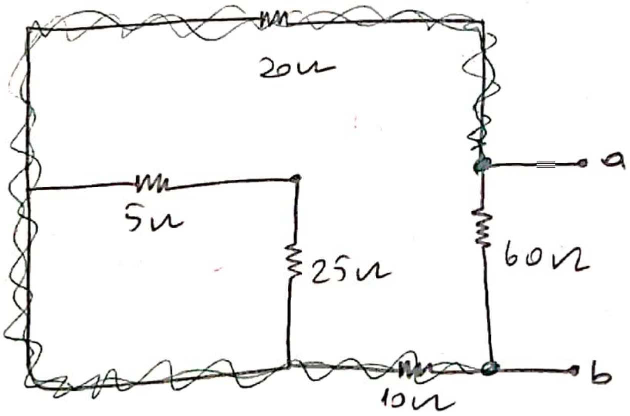
$$V_2 = 15\,V$$

$$i_1 = \frac{9-15}{20} = -0.3\,A$$

$$i_{sc} = (1.8 + i_1)$$
$$= \underline{\underline{1.5\,A}}$$

$$R_{Th} = \frac{30}{1.5} = 20\,\Omega$$

b)

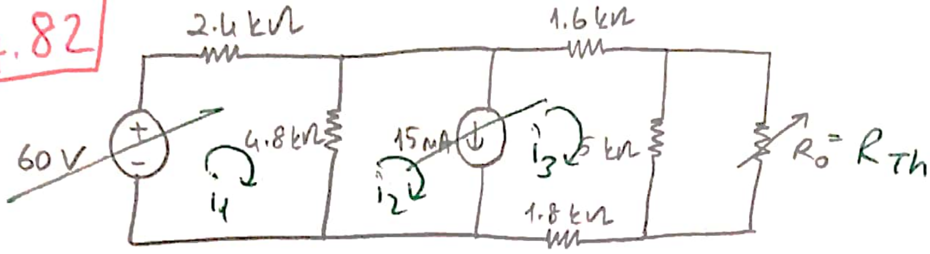


$$R_{Th} = 60 \parallel (20+10)$$

$$R_{Th} = \frac{60 \cdot 30}{(60+30)} = \frac{60 \cdot \cancel{30}}{\cancel{90}_{3}} = \underline{\underline{20\,\Omega}}$$

=

4.82



a) Find $R_{Th} \Rightarrow \left[(2.4k \,//\, 4.8k) + 1.6k + 1.8k\right] \,//\, 5k \rightarrow \boxed{R_{Th} = 2.5\,k\Omega}$ ($= R_o$)

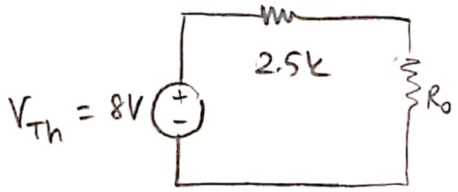
b) $7.2k\,i_1 - 4.8k\,i_2 = 60$

$-4.8k\,i_1 + 4.8k\,i_2 + 8.4\,i_3 = 0$

$i_2 - i_3 = 15\,mA$

$\Rightarrow i_1 = 19.4\,mA \quad i_2 = 16.6\,mA \quad i_3 = 1.6\,mA$

$V_{Th} = 5k\,i_3 = 8\,V$



$P_{R_o} = I^2 R = (0.0016)^2 \cdot 2500$

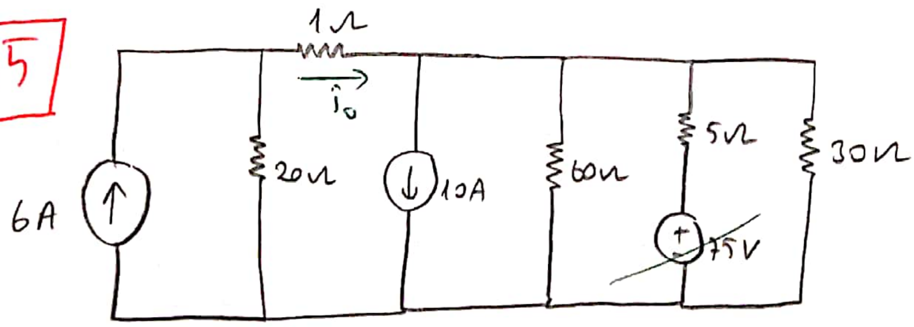
$= 0.0064$ watt

c) Closest to 2.5k is $\rightarrow$ 2.7 kΩ

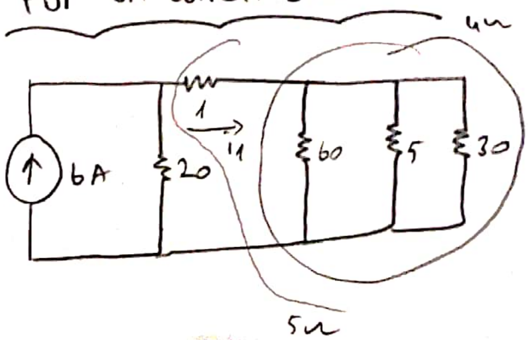
$$v_{2.7k} = \frac{2.7k}{2.7k + 2.5k} \cdot 8 = 4.15\,V$$

$$P_{2.7k} = \frac{v^2}{R} = \frac{(4.15)^2}{2700} = 0.006\ W.$$

4.95



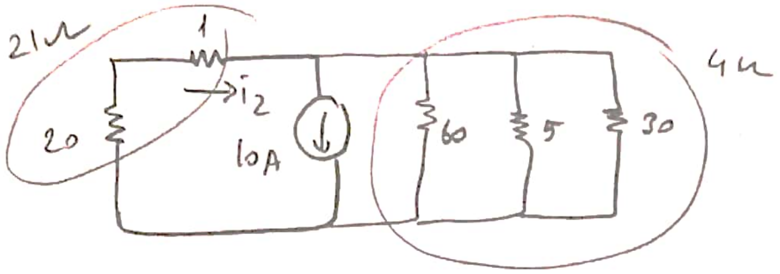
For 6A current source



$30 \,//\, 5 \,//\, 60 = 4\Omega$

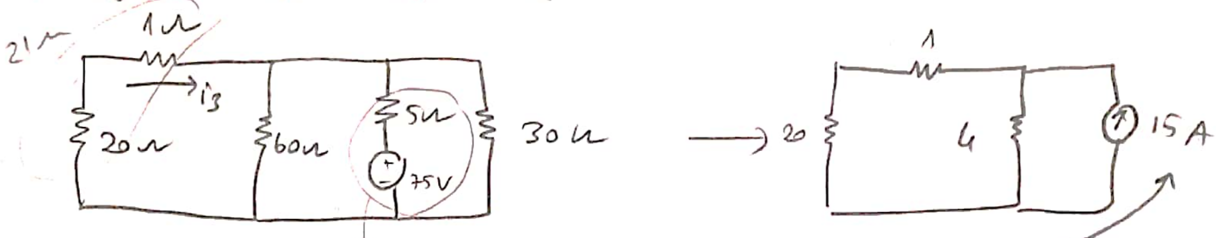
$$i_1 = \frac{20}{20+5} \cdot 6 = 4.8\,A$$

For 10A current source



$$i_2 = \frac{4}{21+4} \cdot 10 = 1.6\ A$$

For 75 voltage source



V = IR

75 = I·5

I = 15

$$i_3' = \frac{4}{25} \cdot 15 = 2.4A$$

Ters yön old. için

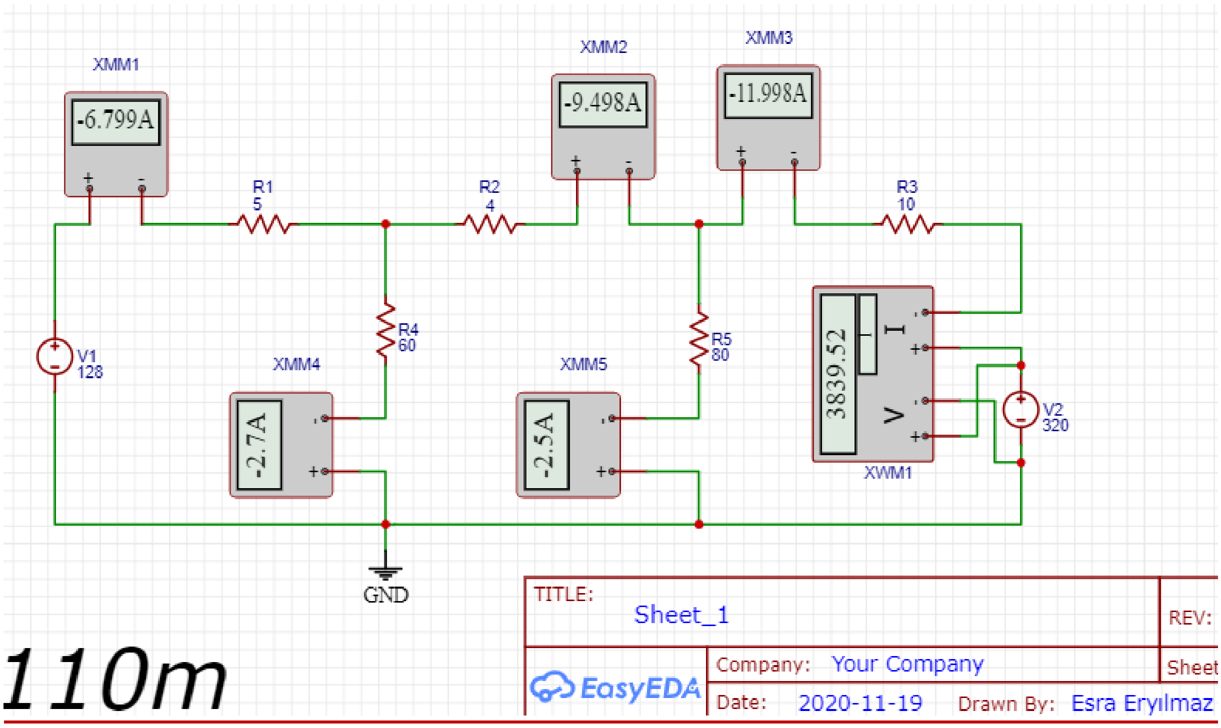
−2.4 A

$$i_0 = i_1 + i_2 + i_3 = 4.8 + 1.6 - 2.4$$

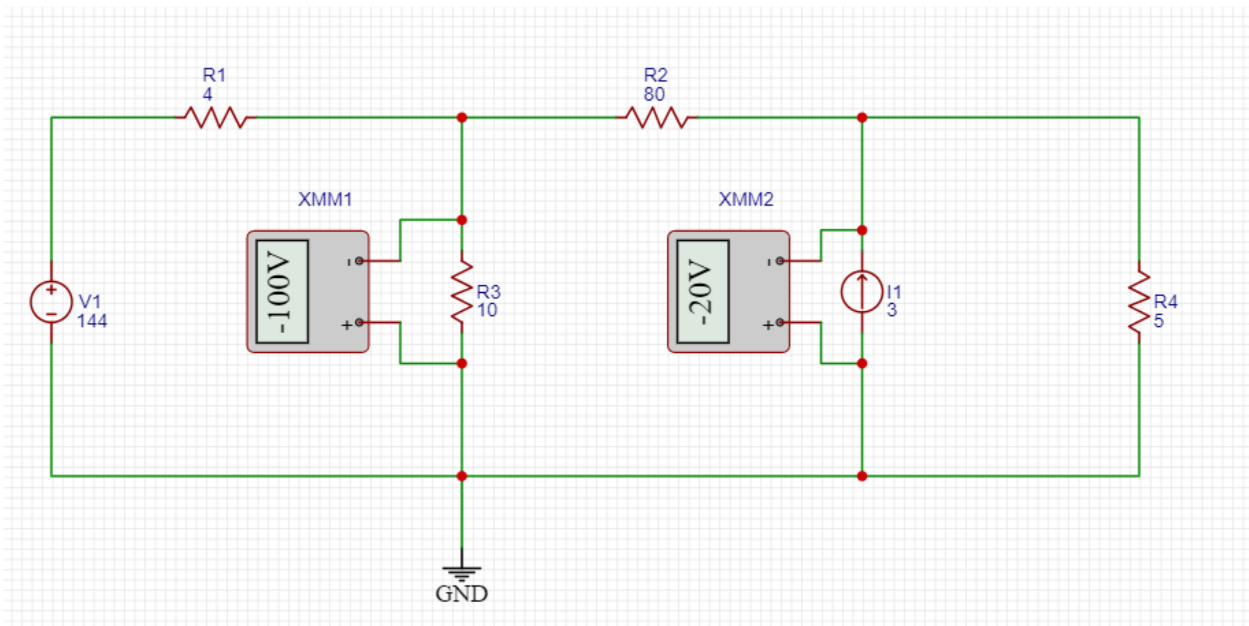
$$= 4.A$$

EasyEDA simulations

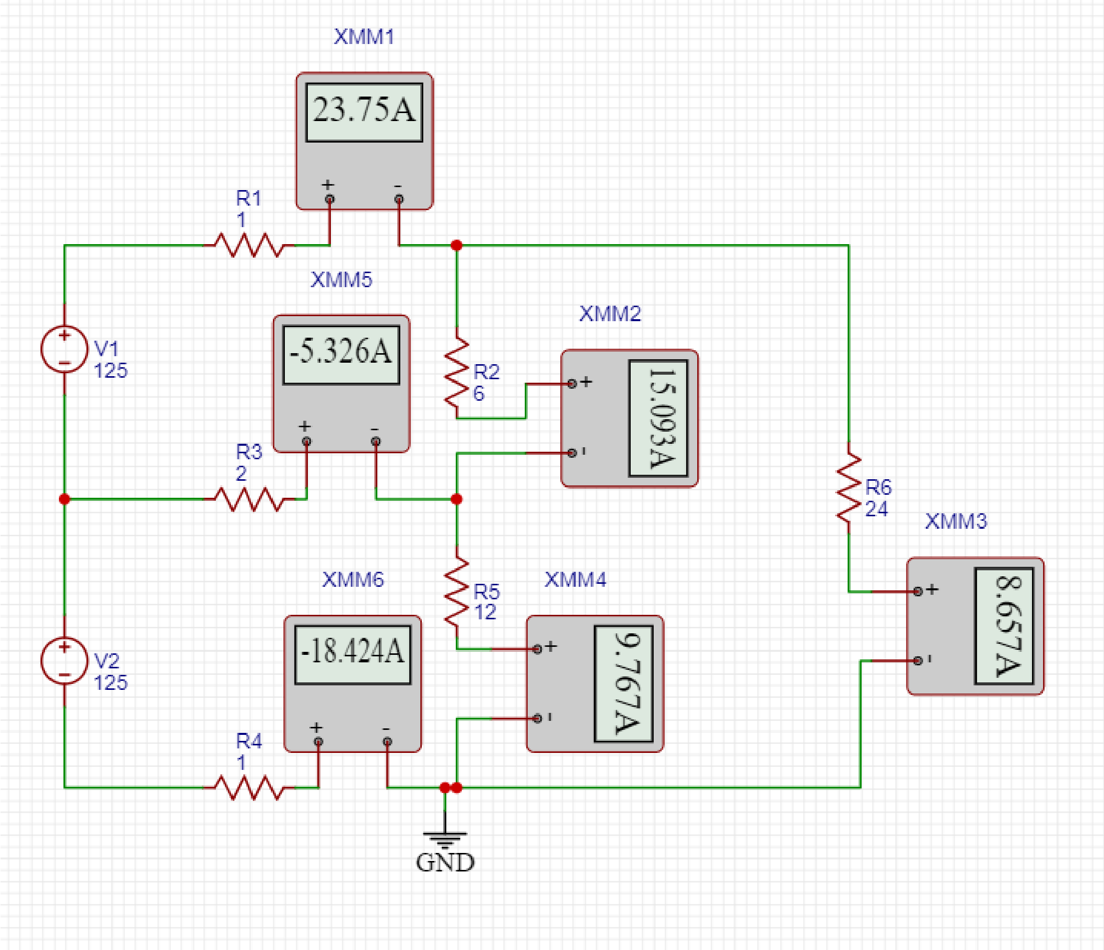
- **4.11**



- **4.12**

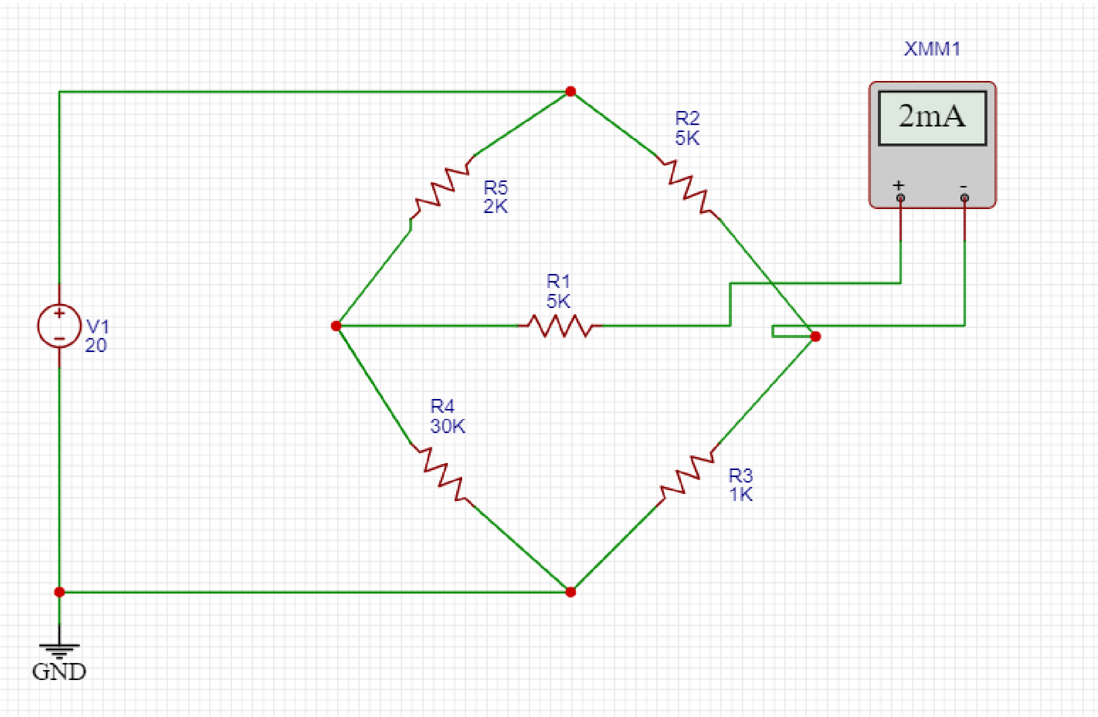


- **4.15**



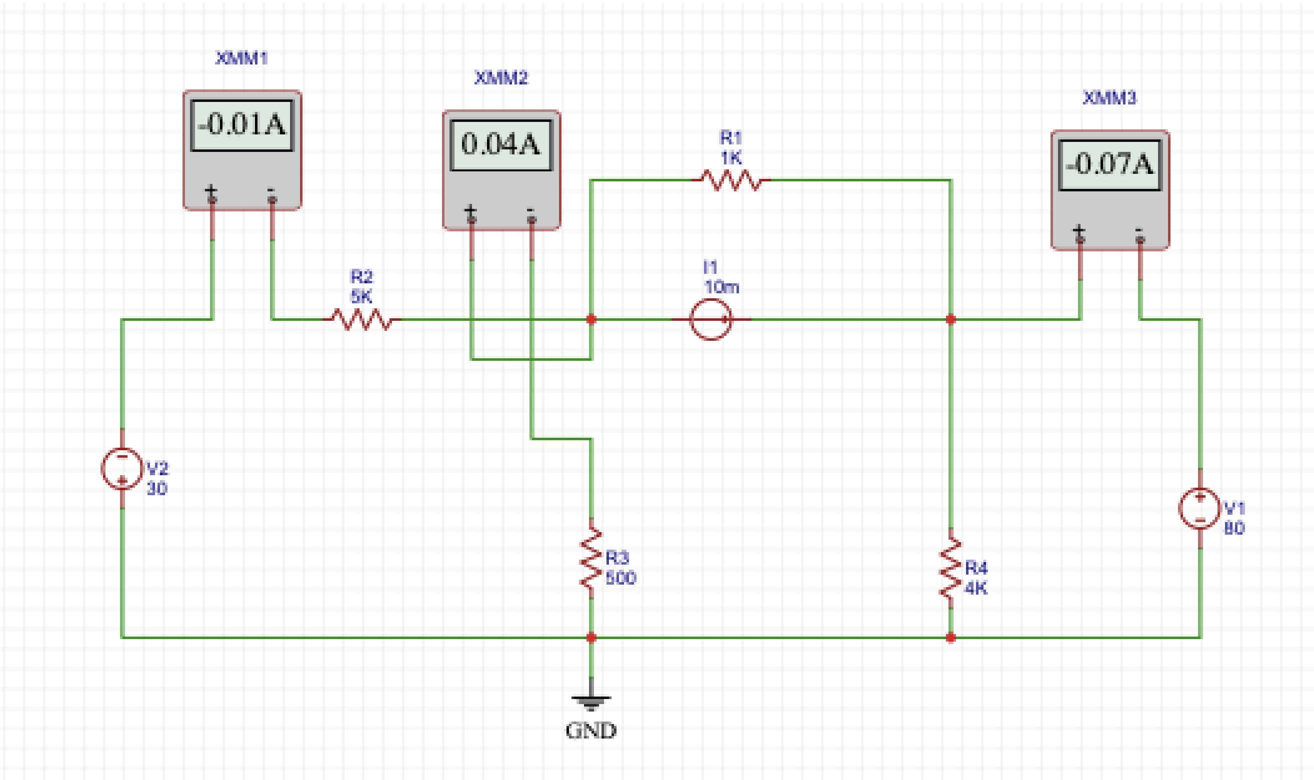
XMM1
23.75A
R1
1
XMM5
-5.326A
XMM2
15.093A
R2
6
V1
125
R3
2
R6
24
XMM3
8.657A
XMM6
-18.424A
R5
12
XMM4
9.767A
V2
125
R4
1
GND

- **4.24**

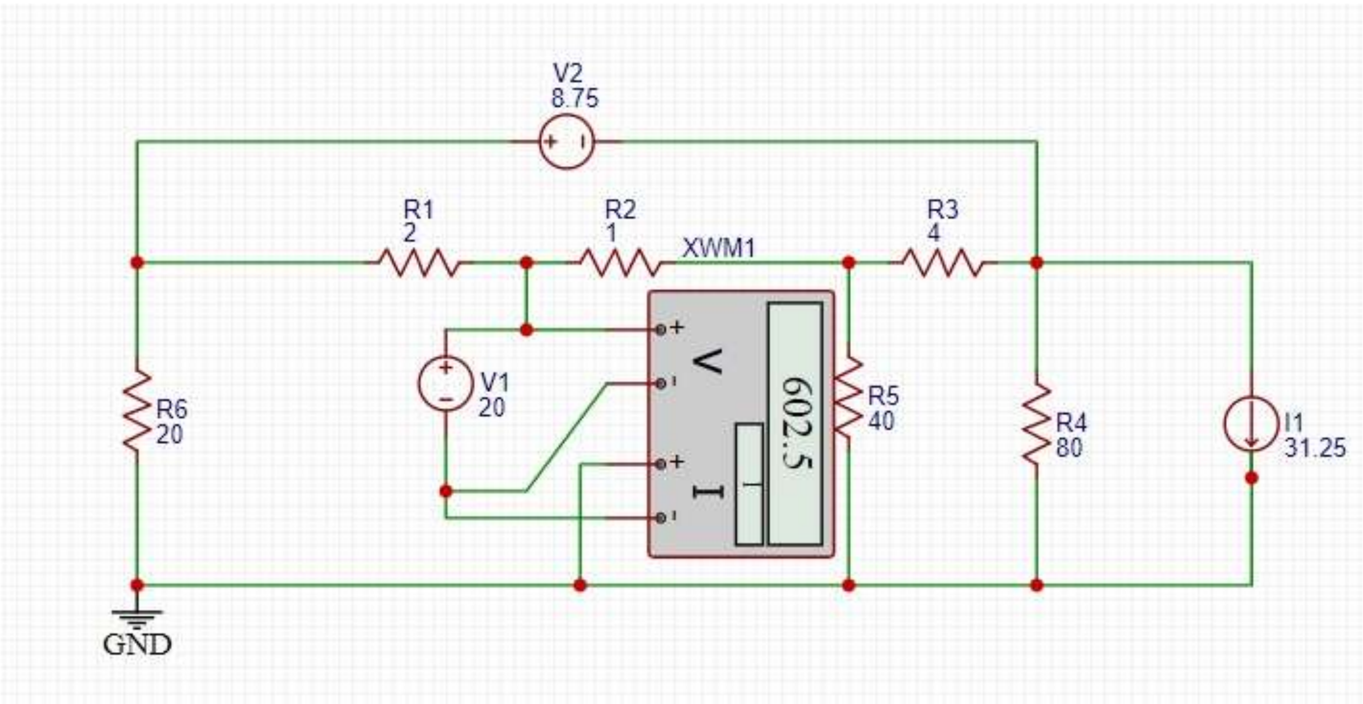


XMM1
2mA
R2
5K
R5
2K
R1
5K
V1
20
R4
30K
R3
1K
GND

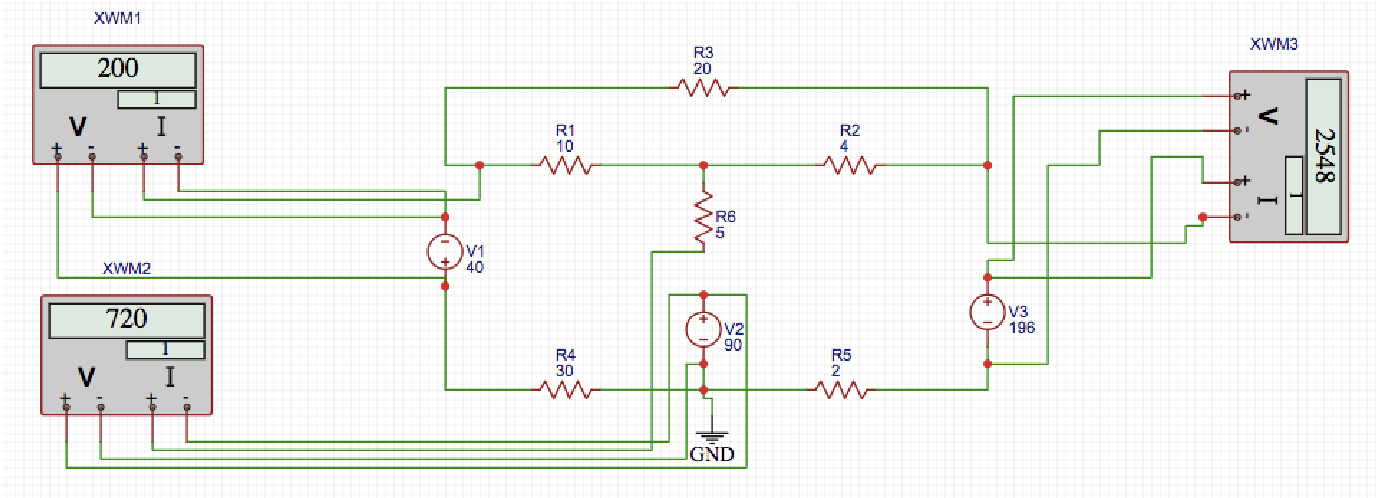
- **4.27**


XMM1
-0.01A
XMM2
0.04A
XMM3
-0.07A
R1
1K
R2
5K
I1
10m
V2
30
R3
500
R4
4K
V1
80
GND

- **4.30**

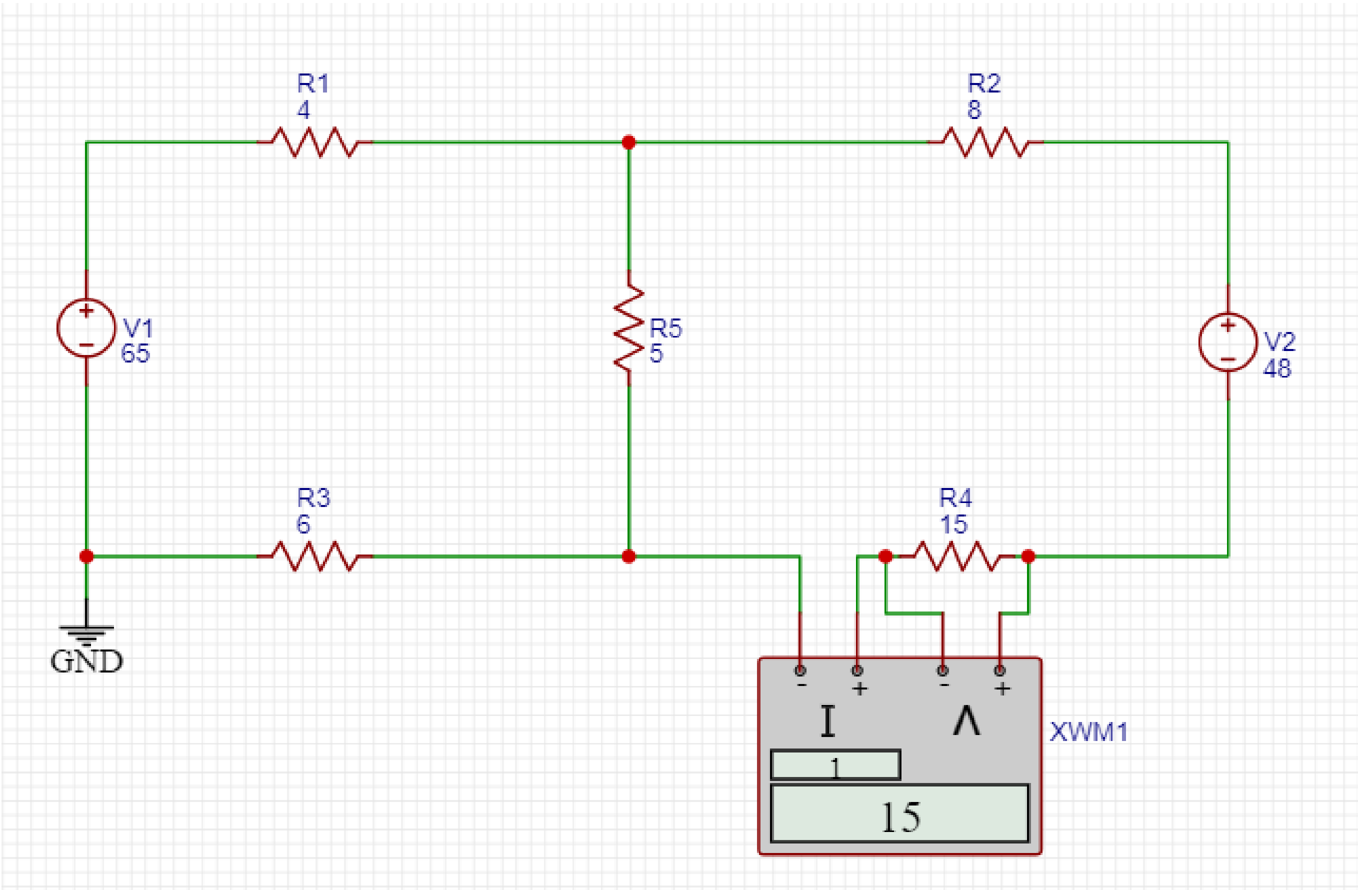

V2
8.75
R1
2
R2
1
XWM1
R3
4
V
602.5
I
R6
20
V1
20
R5
40
R4
80
I1
31.25
GND

- **4.36**



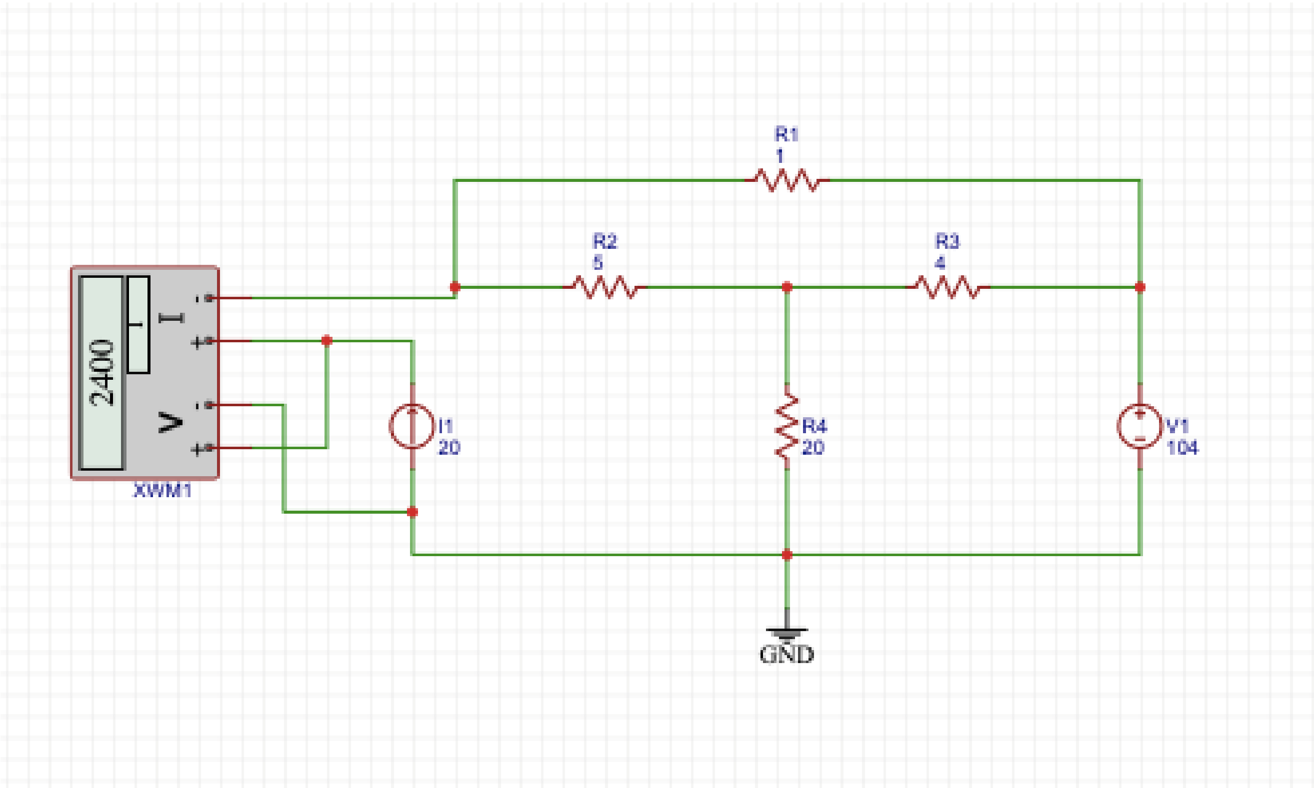
XWM1
200
V
I
XWM2
720
V
I
XWM3
2548
V
I
R1
10
R2
4
R3
20
R4
30
R5
2
R6
5
V1
40
V2
90
V3
196
GND

- **4.39**

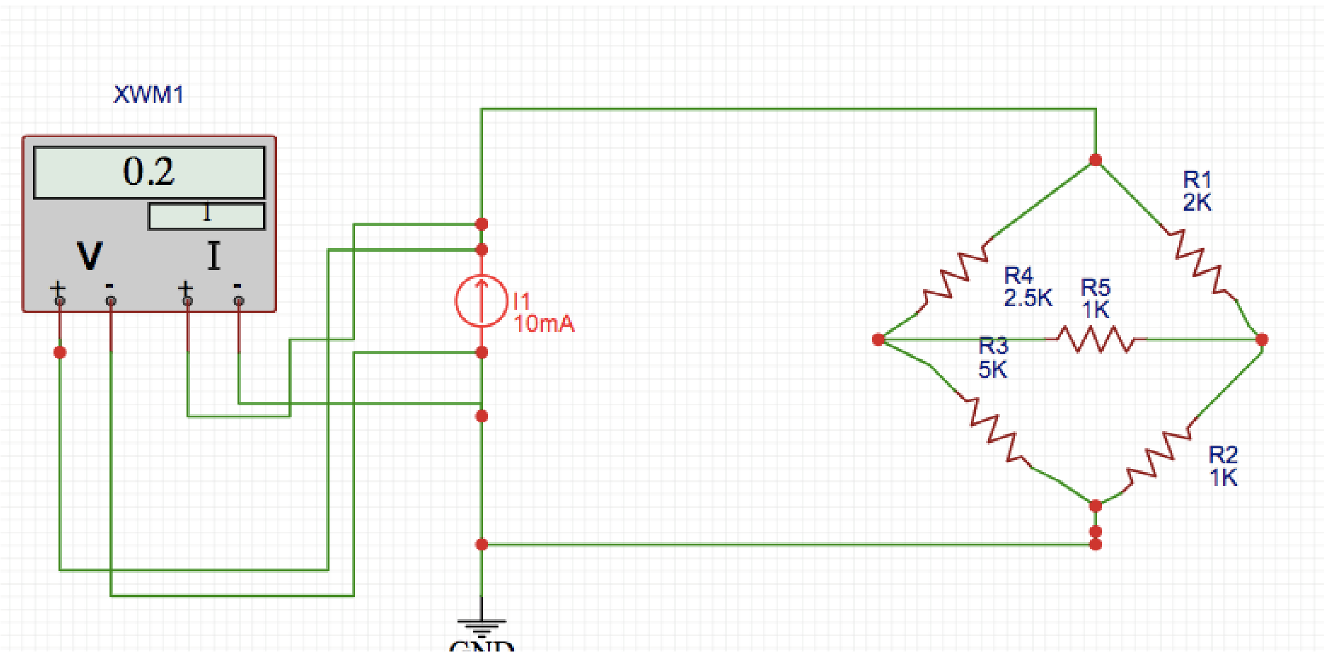


R1
4
R2
8
R3
6
R4
15
R5
5
V1
65
V2
48
GND
XWM1
I
V
15

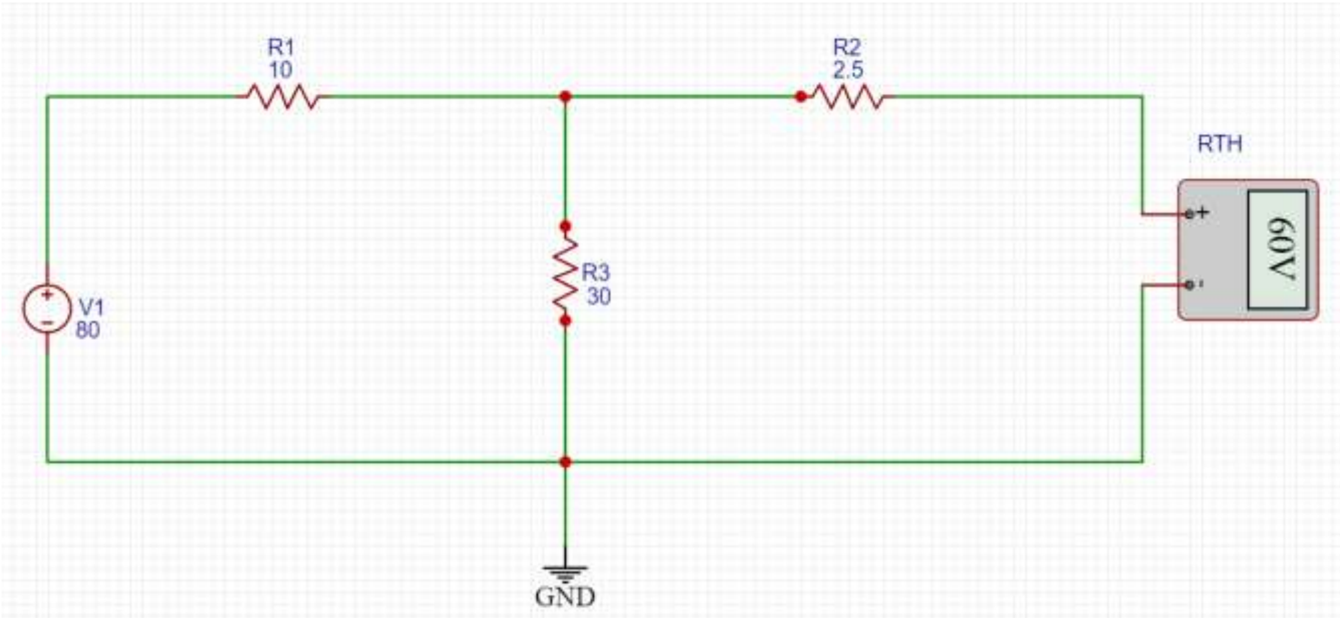
- **4.46**


R1
1
R2
5
R3
4
2400
XWM1
I1
20
R4
20
V1
104
GND

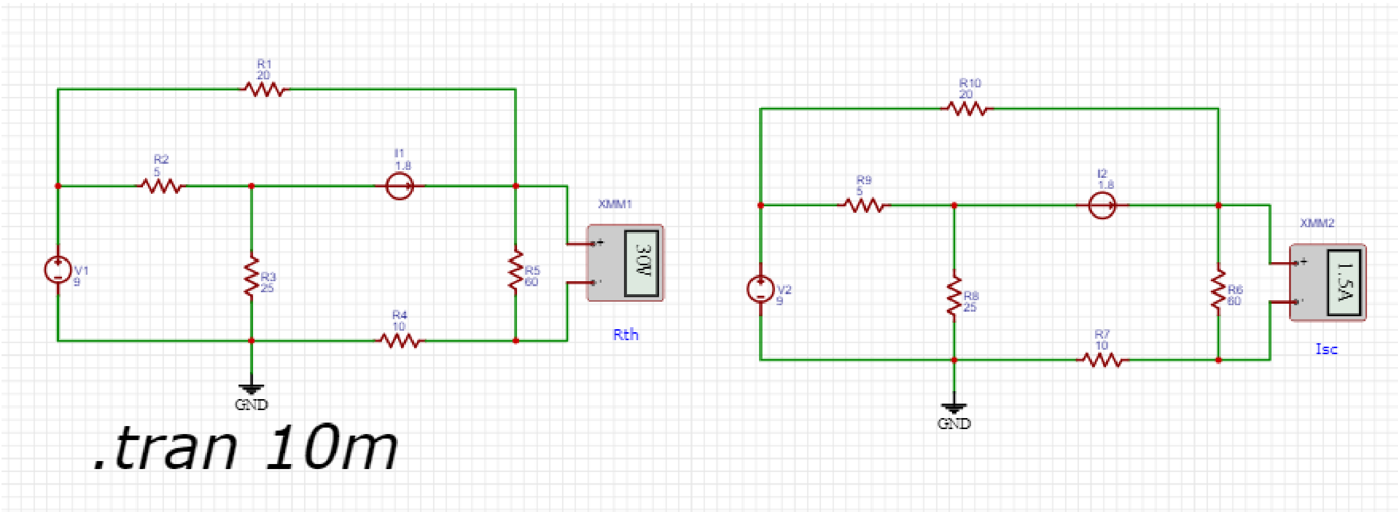
- **4.54**


XWM1
0.2
V
I
I1
10mA
R1
2K
R4
2.5K
R5
1K
R3
5K
R2
1K

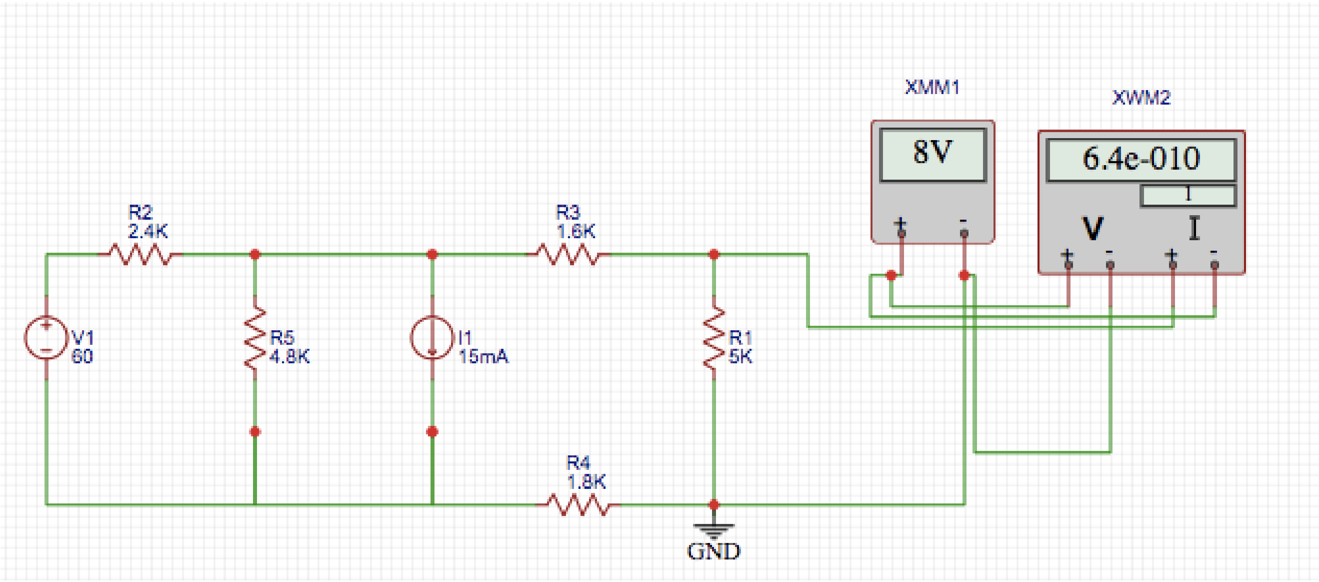
- **4.64**


R1
10
R2
2.5
RTH
60V
R3
30
V1
80
GND

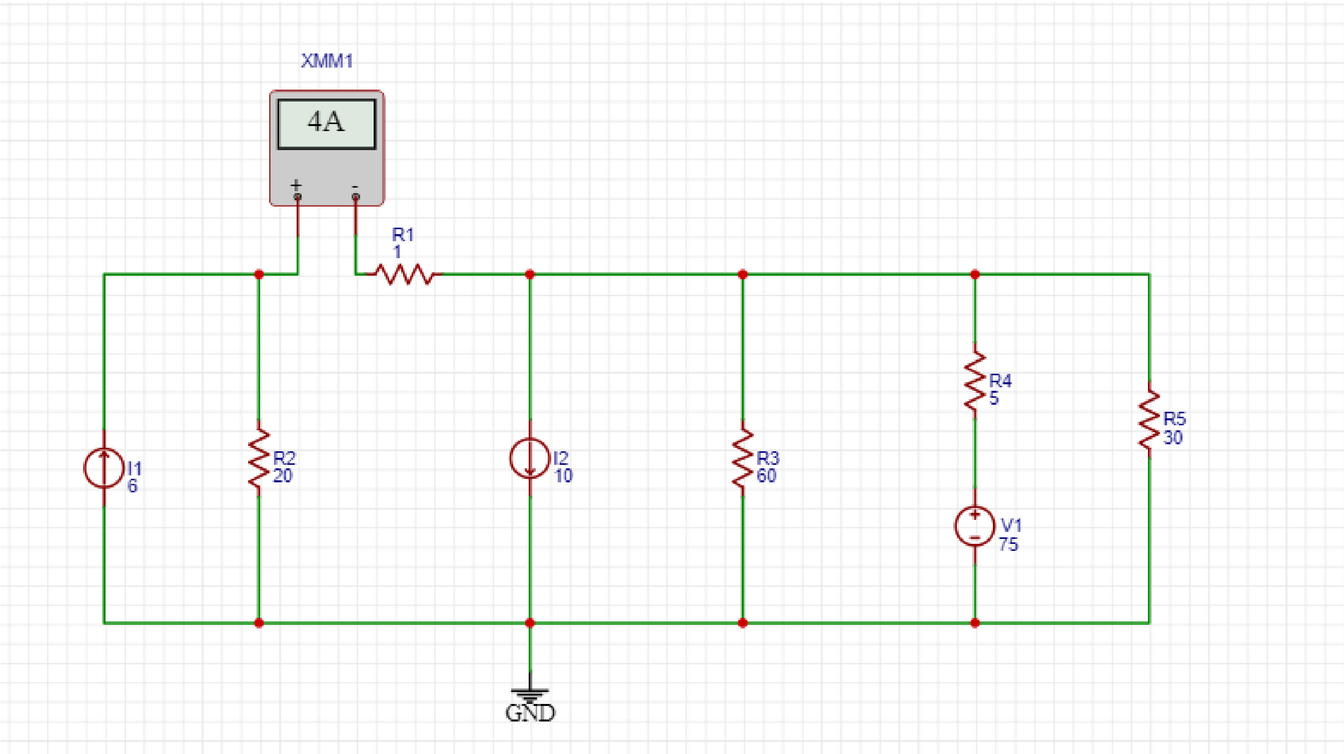
- **4.78**


R1
20
R2
5
I1
1.8
XMM1
30V
V1
9
R3
25
R5
60
R4
10
Rth
GND
.tran 10m
R10
20
R9
5
I2
1.8
XMM2
1.5A
V2
9
R8
25
R6
60
R7
10
Isc
GND

- **4.82**


XMM1
8V
XWM2
6.4e-010
V
I
R2
2.4K
R3
1.6K
V1
60
R5
4.8K
I1
15mA
R1
5K
R4
1.8K
GND

- **4.95**


XMM1
4A
R1
1
I1
6
R2
20
I2
10
R3
60
R4
5
V1
75
R5
30
GND