4-1) a) 12 branches

b) All the branches except the one with 25 mA current source.

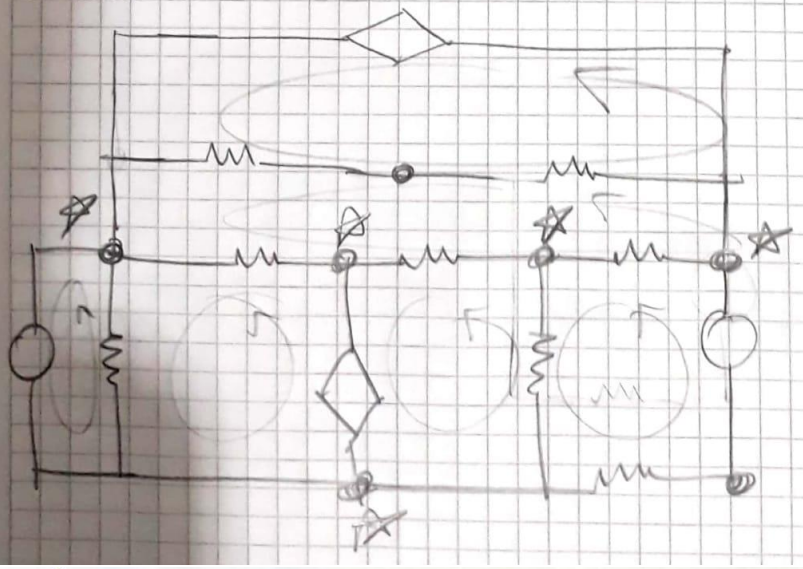
c) 10 essential branches

d) 9 essential branches (except the current source)

e) 7 nodes

f) 5 essential nodes

g) 6 meshes



4-2) a) 9 equations for 9 essential branches

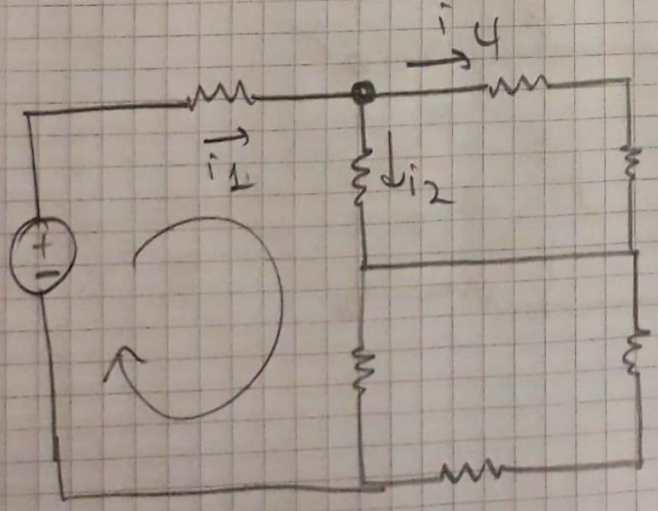
b) KCL formula → (n − 1) = 5 − 1 = 4 equations
(n = node)

c) b − 4 = 9 − 4 = 5 equations

4-3) a) V_S and R_1 has the same current,
R_4 and R_6 has the same current and
R_5 and R_7 has the same current
=> 8 (different components) 8 - 3 = 5 different unknown currents

b) There are 3 essential nodes
ne - 1 = 2 independent KCL equations

c)

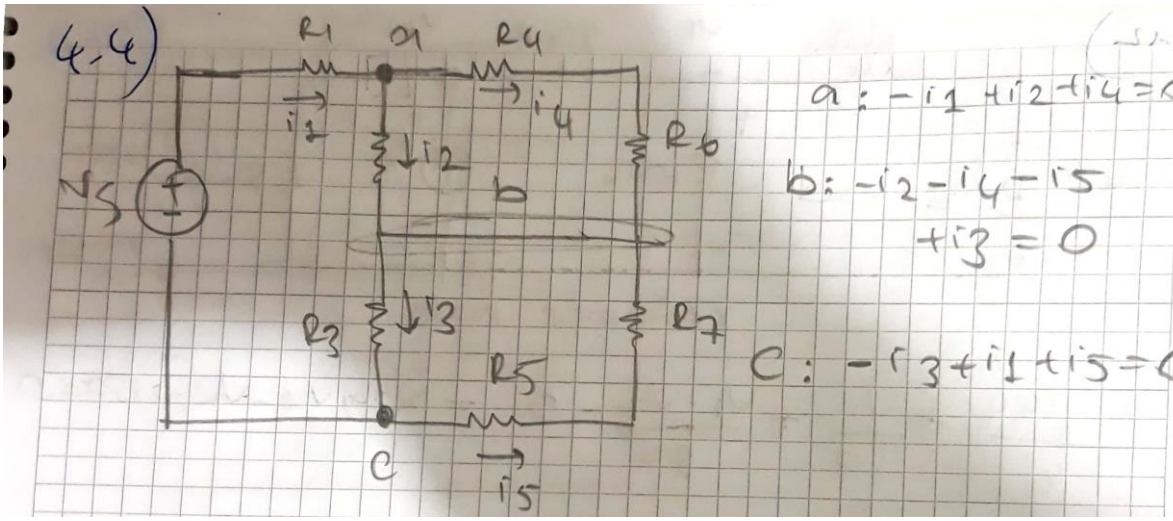


$-i_1 + i_2 + i_4 = 0$

d) 3 for 3 meshes

e) $V_S - R_1 i_2 - R_2 i_2 - R_3 i_3 = 0$

(4.4)

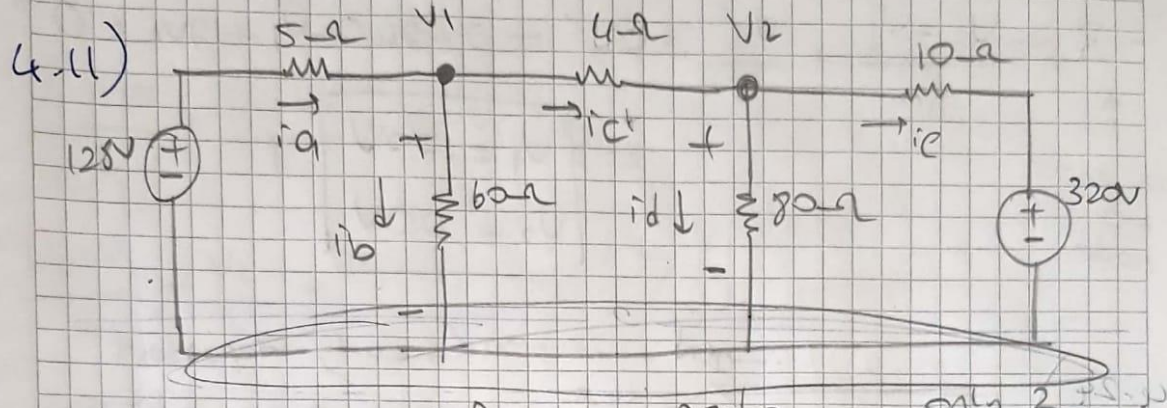


a: $-i_1 + i_2 + i_4 = 0$

b: $-i_2 - i_4 - i_5 + i_3 = 0$

c: $-i_3 + i_1 + i_5 = 0$

4.11)



for V_1:

$$\frac{V_1-128}{5}+\frac{V_1}{60}+\frac{V_1-V_2}{4}=0 \Rightarrow 12V_1-1536+V_1+15V_1-15V_2=0$$

$$28V_1-15V_2=1536$$

for V_2:

$$\frac{V_2-V_1}{4}+\frac{V_2}{80}+\frac{V_2-320}{10}=0 \Rightarrow 20V_2-20V_1+V_2+8V_2-2560=0$$

$$-20V_1+29V_2=2560$$

$$i_a=\frac{128-162}{5}=-6.8A$$

$$i_b=\frac{162}{60}=2.7A$$

$$i_c=\frac{162-200}{4}=-9.5A$$

$$i_d=\frac{200}{80}=2.5A$$

$$i_e=\frac{200-320}{10}=-12A$$

$$\Rightarrow \begin{array}{l} 28V_1-15V_2=1536 \mid 29 \\ -20V_1+29V_2=2560 \mid 28 \end{array}$$

$$+$$

$$-300V_2+812V_2=102400$$

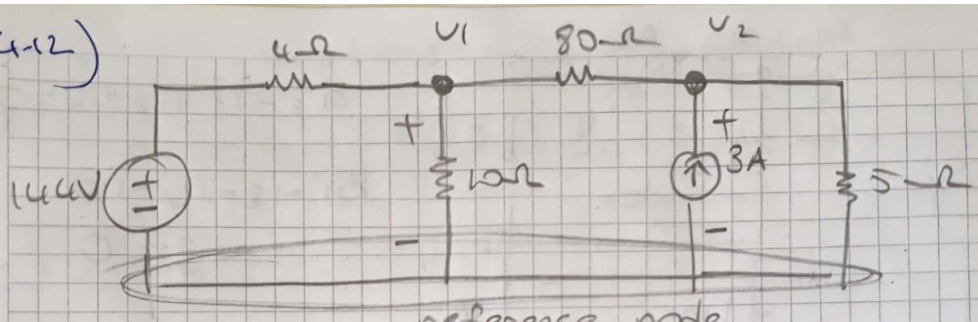
$$\boxed{V_2=200V}$$

$$\boxed{V_1=162V}$$

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

$$=-3840W \ (3840W \text{ developed})$$

4-12)



$$\frac{V_1-144}{4}+\frac{V_1}{10}+\frac{V_1-V_2}{80}=0 \Rightarrow 20V_1-2880+8V_1+V_1-V_2=0$$

$$29V_1-V_2=2880$$

$$\frac{V_2-V_1}{80}+\frac{V_2}{5}-3=0 \Rightarrow V_2-V_1+16V_2-240=0$$

$$-V_1+17V_2=240 \quad |29$$

$$29V_1-V_2=2880$$

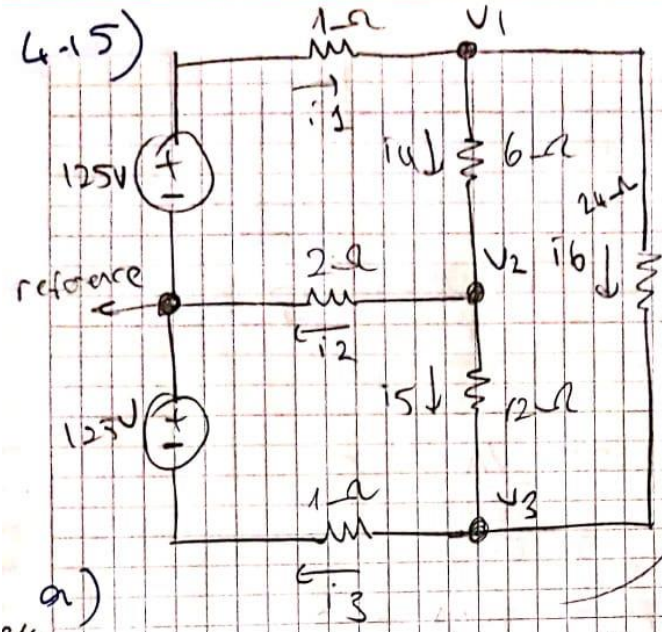
$$-29V_1+493V_2=6960$$

$$492V_2=9840$$

$$V_1=100V$$

$$V_2=20V$$

4.15)



$$29V_1 - 4V_2 - V_3 = 3000$$
$$-2V_1 + 9V_2 - V_3 = 0$$
$$-V_1 - 2V_2 + 27V_3 = -3000$$

$$\begin{bmatrix} 29 & -4 & -1 \\ -2 & 9 & -1 \\ -1 & -2 & 27 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 3000 \\ 0 \\ -3000 \end{bmatrix}$$

$$AX = b$$
$$X = A^{-1}b$$

$$X = \begin{bmatrix} 101.24 \\ 10.66 \\ -106.57 \end{bmatrix} \begin{matrix} V_1 \\ V_2 \\ V_3 \end{matrix}$$

a)

24/ $\frac{V_1 - 125}{1} + \frac{V_1 - V_2}{6} + \frac{V_1 - V_3}{24} = 0$

12/ $\frac{V_2 - V_1}{6} + \frac{V_2}{2} + \frac{V_2 - V_3}{12} = 0$

24/ $\frac{V_3 + 125}{1} + \frac{V_3 - V_2}{12} + \frac{V_3 - V_1}{24} = 0$

$P = IV = I^2R$

$$i_1 = \frac{125 - 101.24}{1} = 23.76A$$

$$i_2 = \frac{10.66}{2} = 5.33A$$

$$i_3 = \frac{-106.57 + 125}{1} = 18.43A$$

$$i_4 = \frac{101.24 - (10.66)}{6} = 15.10A$$

$$i_5 = \frac{10.66 - (-106.57)}{12} = 9.77A$$

$$i_6 = \frac{101.24 - (-106.57)}{24} = 8.66A$$

b) battery

$P_{dev} = 125(23.76) + 125(18.43)$

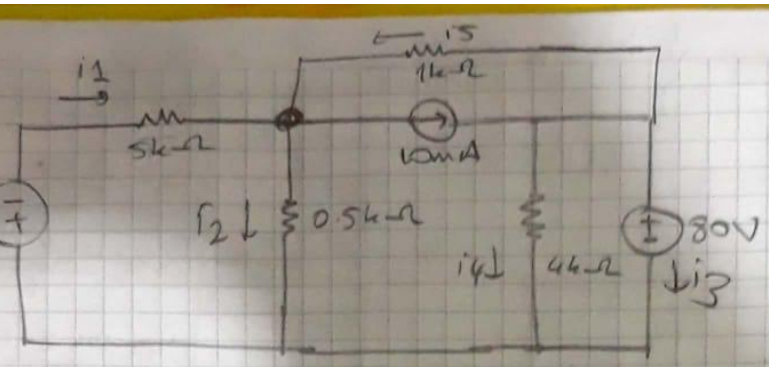
$P_{dev} = 5273.75W$

$P_{dis} = (23.76)^2 \cdot 1 + (5.33)^2 \cdot 2 + (18.43)^2 \cdot 1 + (15.10)^2 \cdot 6$

resistors $+ (9.77)^2 \cdot 15 + (8.66)^2 \cdot 24$

$= 5273.75W$

(4.27)



a)

$$\frac{V_A+30}{5000} + \frac{V_A-80}{1000} + 0.01 + \frac{V_A}{500} = 0$$

(5) (10)

$$\Rightarrow V_A + 30 + 10V_A - 400 + 50 + 5V_A = 0$$

$$\Rightarrow 16V_A = 320$$

$$\boxed{V_A = 20V}$$

$$i_1 = (30-20)/5000 = -10\,mA$$

$$i_2 = 20/500 = 40\,mA$$

$$i_4 = 80/4000 = 20\,mA$$

$$i_5 = (80-20)/1000 = 60\,mA$$

$$i_3 = 10mA - i_4 - i_5 \Rightarrow i_3 = -70\,mA$$

b) $P_{30V} = 30(-0.01) = -0.3W$

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

$P_{10mA} = (-60)(0.01) = -0.6W$

$+$

$6.5W.$

$P_{4k} = 60^2/4000 = 1.6W$

$P_{1k} = 60^2/1000 = 3.6W$

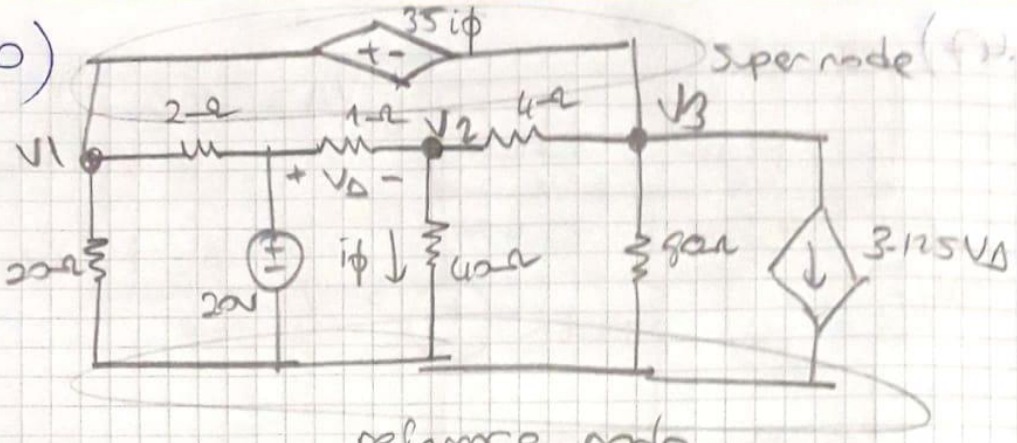
$P_{500} = (0.04)^2 \cdot 500 = 0.8W$

$P_{5k} = (0.01)^2 \cdot 5000 = 0.5W$

$+$

$6.5W$

4.30)



from supernode:

$$\frac{V_3-V_2}{4}+\frac{V_3}{80}+3.125+\frac{V_1}{20}+\frac{V_1-20}{2}=0$$

from V_2:

$$\frac{V_2-V_3}{4}+\frac{V_2-20}{1}+\frac{V_2}{40}=0$$

80/

$$=>\frac{V_3}{4}-\frac{V_2}{4}+\frac{V_3}{80}+3.125+\frac{V_1}{20}+\frac{V_1}{2}-10=0$$

40/

$$\frac{V_2}{4}-\frac{V_3}{4}+V_2-20+\frac{V_2}{40}=0$$

=> after solving the equations ---

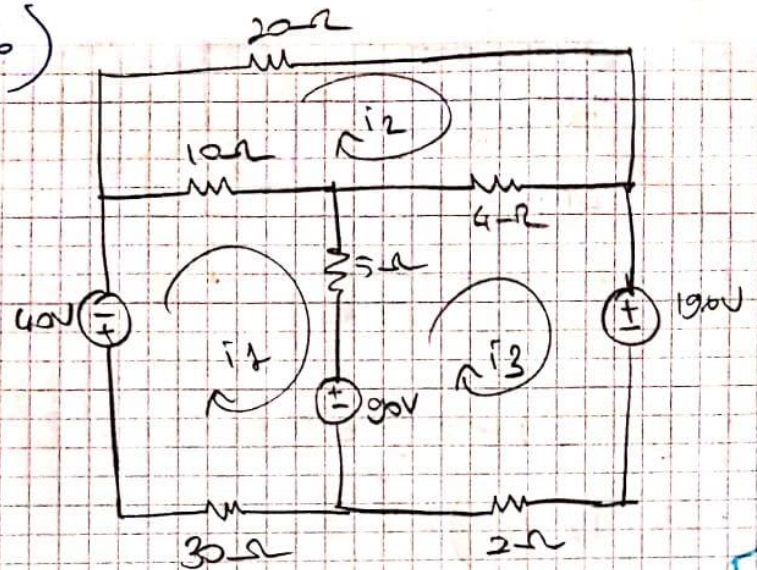
$$V_1=-20.25V,\ V_2=10V,\ V_3=-29V$$

current over 20V source

$$i_{20V}=\frac{-0.25}{2}+\frac{10}{1}=30.125A$$

$$P=20(30.125)=602.5W$$

4-36)



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

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

$$190+2i_3-90+5(i_3-i_1)+4(i_3-i_2)=0$$

$$\begin{bmatrix} v_1 \\ v_2 \\ v_3 \end{bmatrix} = \begin{bmatrix} -5 \\ -3 \\ -13 \end{bmatrix}$$

$$45i_1-10i_2-5i_3=-130$$
$$-10i_1+34i_2-4i_3=0$$
$$-5i_1-4i_2+11i_3=-100$$

$$\Rightarrow \begin{bmatrix} 45 & -10 & -5 \\ -10 & 34 & -4 \\ -5 & -4 & 11 \end{bmatrix}\begin{bmatrix} v_1 \\ v_2 \\ v_3 \end{bmatrix} = \begin{bmatrix} -130 \\ 0 \\ -100 \end{bmatrix}$$

a) $P_{40V} = 40(-5) = -200W$ (delivered)

$P_{90V} = 90(-5-(-13)) = 720W$ (absorbed)

$P_{190V} = 190(-13) = -2545W$ (delivered)

$P_{Del} = 2745W$

b) $P_{4\Omega} = 400W$ $\quad P = IV = I^2R$

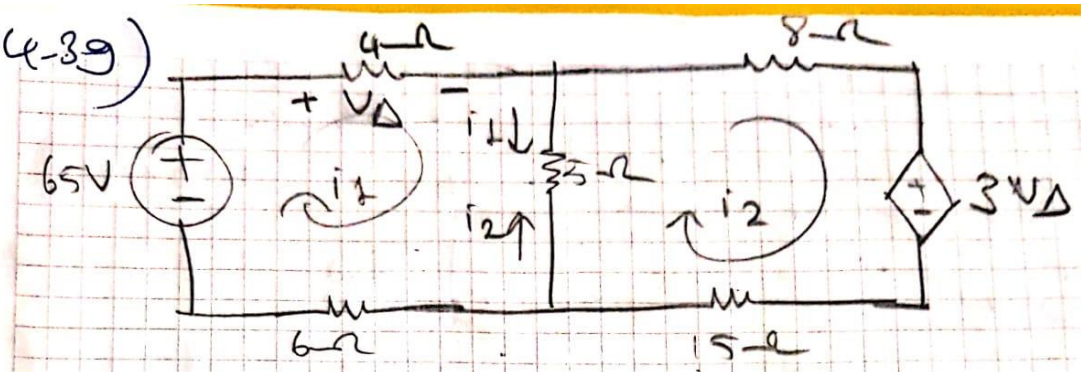
$P_{5\Omega} = 320W$

$P_{30\Omega} = 750W$ $\quad P_{2\Omega} = 338W$

$P_{10\Omega} = 40W$ $\quad +$

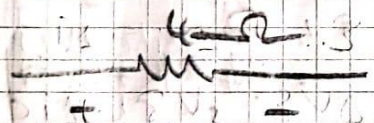
$P_{20\Omega} = 180W$ $\quad 2745W$ ✓

(4-39)



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

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



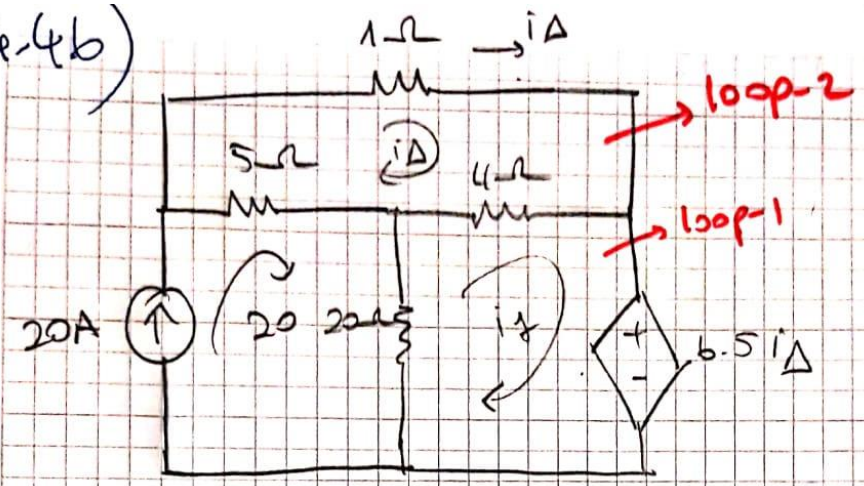
$V_\Delta = 4i_1$

$$\therefore \boxed{\begin{aligned} i_1 &= 4A \\ i_2 &= -1A \\ V_\Delta &= 16V \end{aligned}}$$

$$P = I^2 R$$

$$P_{15\Omega} = (-1)^2 \cdot 15 = 15W$$

4.46)



① $20i_1 - 400 + 4i_1 - 4i_\Delta + 6.5i_\Delta = 0$

$24i_1 + 2.5i_\Delta = 400$

② $10i_\Delta - 4i_1 = 100 \quad | \times 6$

$+$

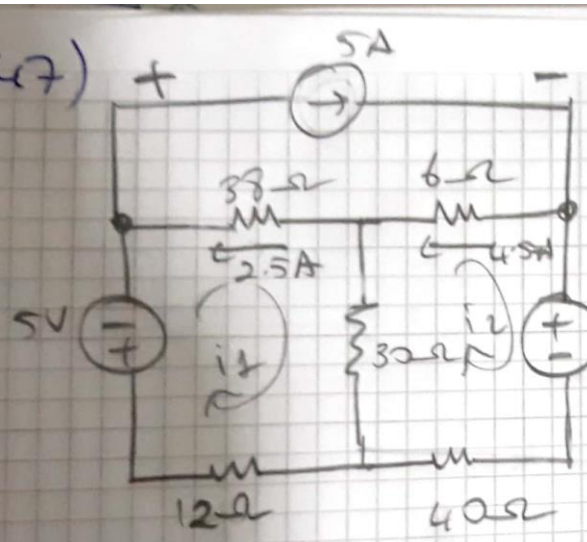
$\Rightarrow 62.5 i_\Delta = 1000 \Rightarrow \boxed{i_\Delta = 16A} \quad \boxed{i_1 = 15A}$

Total power developed by 20A current source:

$V_{20A} = 1i_\Delta + 6.5 i_\Delta = 120V$

$P_{20A} = 20 \cdot 120 = 2400\ W$

4.47)



$V_A = 38(2.5) + 6(4.5)$

$V_A = 122V$

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

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

$\Rightarrow \boxed{i_1 = 2.5A} \quad \boxed{i_2 = 0.5A}$

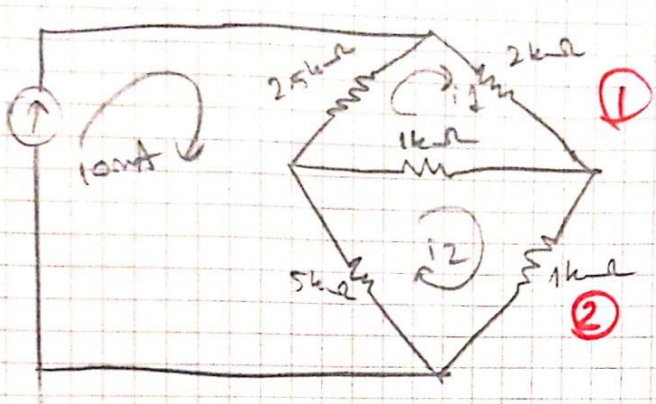
$P_{5A} = V_{5A} \cdot 5 = 122.5$

$= 610W$ (uses 610W)

↓

absorbed

4.54)



① $2500i_1 - 2500(0.01) + 1000i_1 - 1000i_2 + 2000i_1 = 0$

$5500i_1 - 1000i_2 = 25$

② $3000i_2 - 50 + 1000i_2 - 1000i_1 + 1000i_2 = 0$

$7000i_2 - 1000i_1 = 50$

$\Rightarrow i_1 = 6mA$, $i_2 = 8mA$

$P_{10mA} = (2000i_1 + 1000i_2) \times (0.01)$

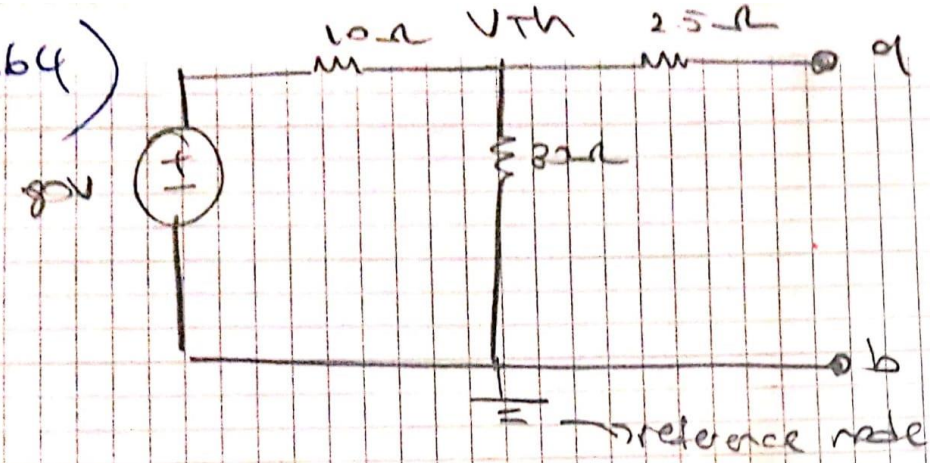
$P_{10mA} = 200mW$

developed

$i_{1k} = -2mA$

$P_{1k} = (-0.002)^2 (1000) = 4mW$

(4.64)



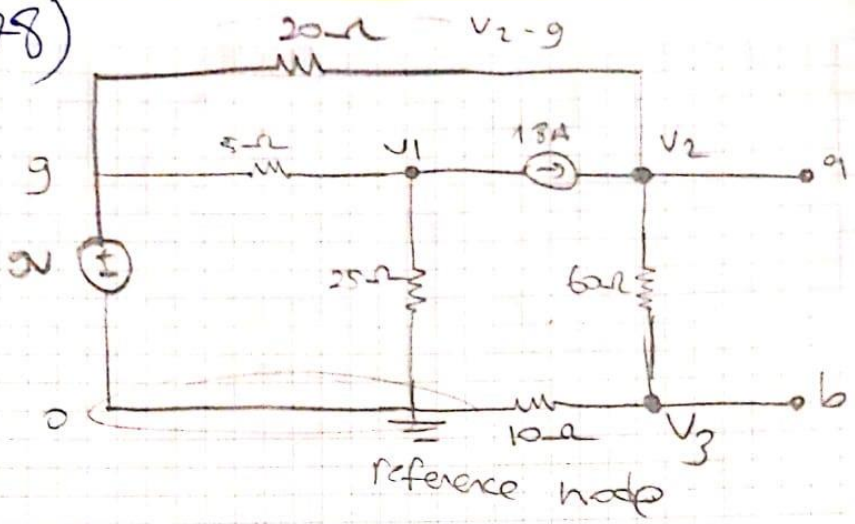
$$\frac{V_{Th}-80}{10} + \frac{V_{Th}}{30} = 0$$

(3)

$$\Rightarrow 3V_{Th} - 240 + V_{Th} = 0 \Rightarrow 4V_{Th} = 240$$

$$\boxed{V_{Th} = 60\,V}$$

4-78)



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

$$\Rightarrow \boxed{V_2 = 35V}$$

$$\frac{V_3 - V_2}{60} + \frac{V_3}{10} = 0$$

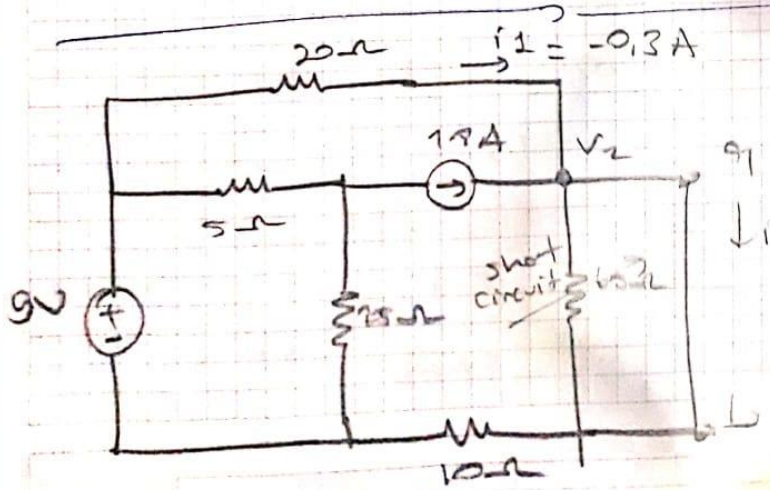
$$\frac{V_3 - 35}{60} + \frac{6V_3}{10} = 0$$

$$\Rightarrow 7V_3 = 35$$

$$\boxed{V_3 = 5V}$$

$V_{ab} = V_{th} = 30V$

with nodal analysis



$\Rightarrow \boxed{V_2 = 15V}$

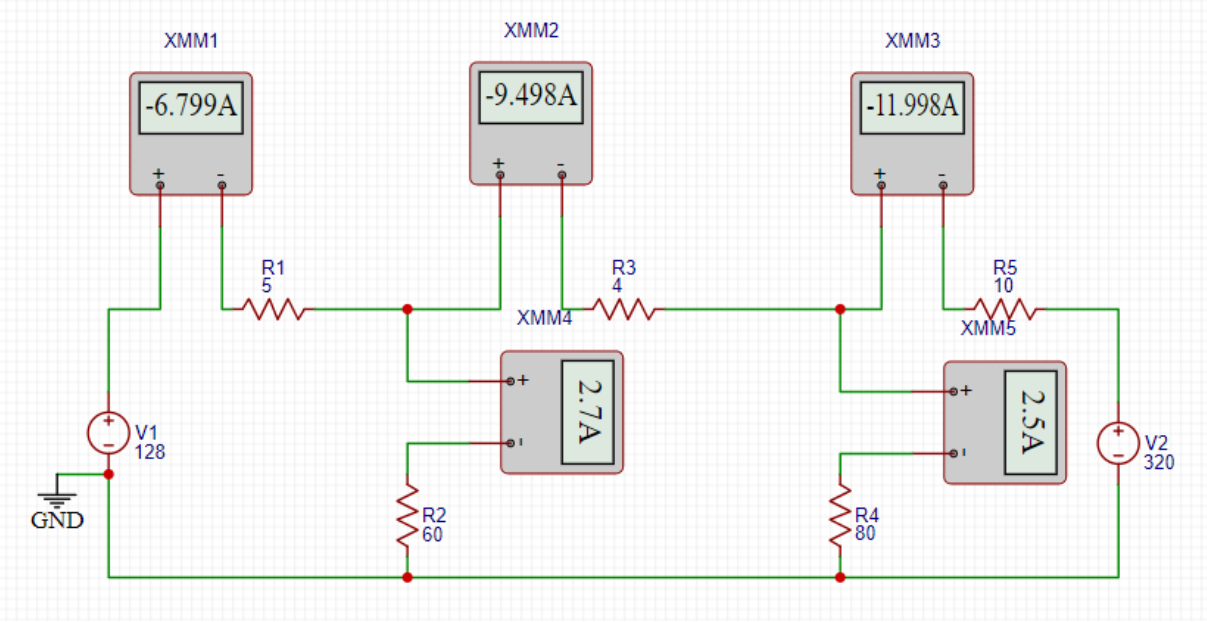
$\boxed{i_2 = 1.5A}$

$R_{th} = \frac{30}{1.5}$

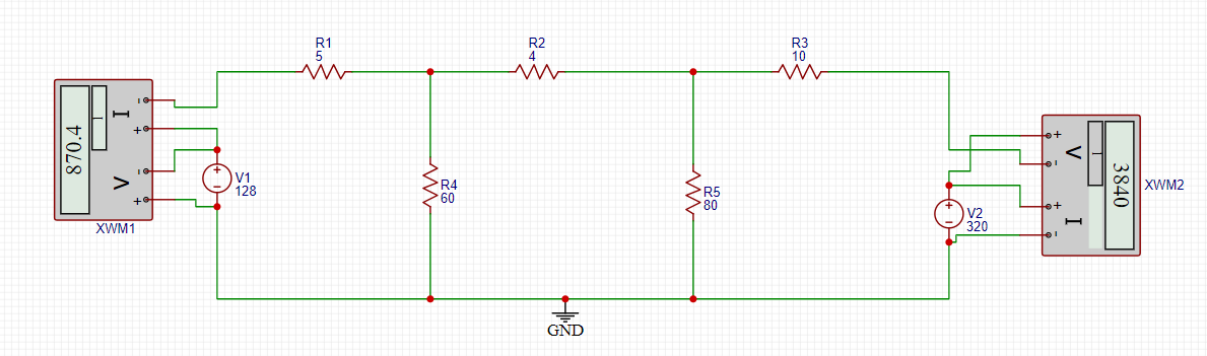
$R_{th} = 20\Omega$

Simulations

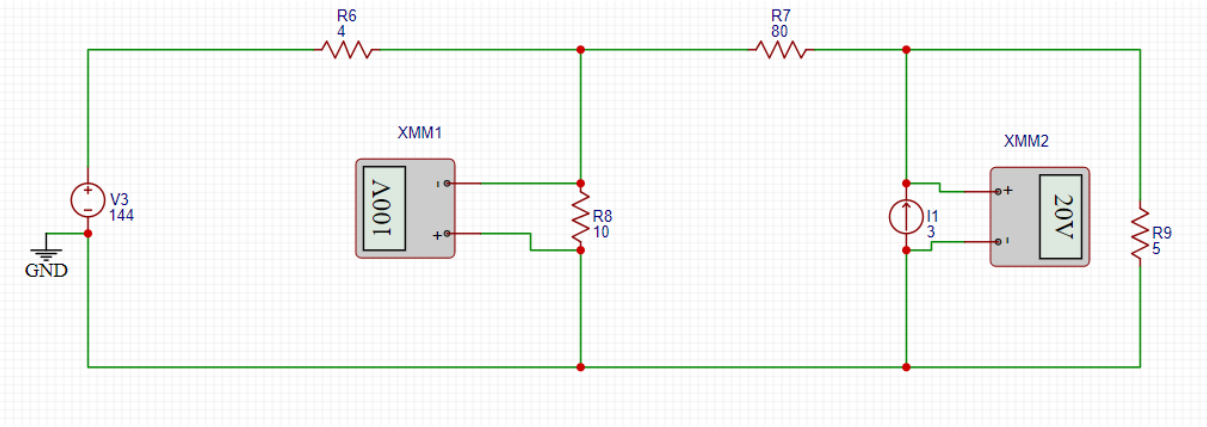
4.11.a



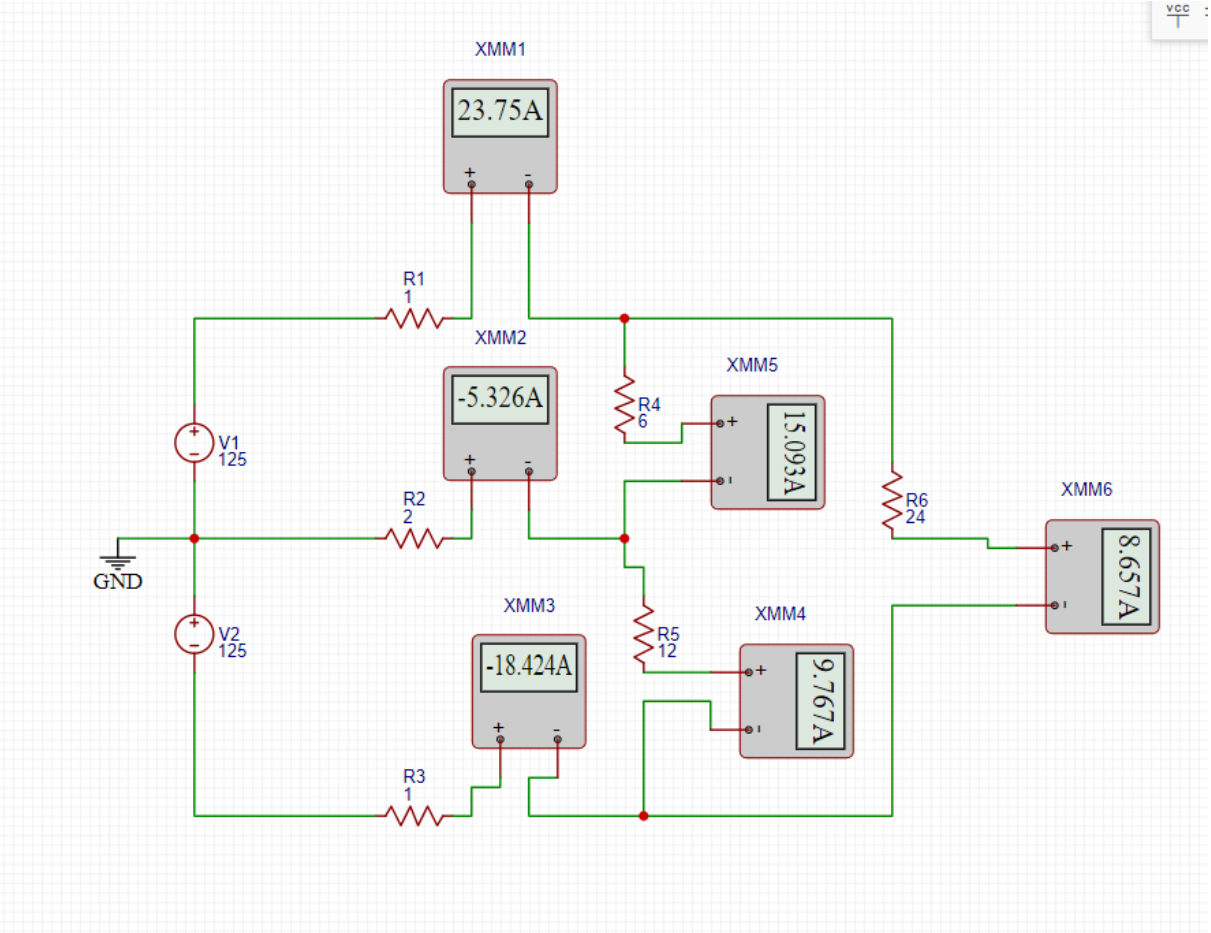
4.11.b



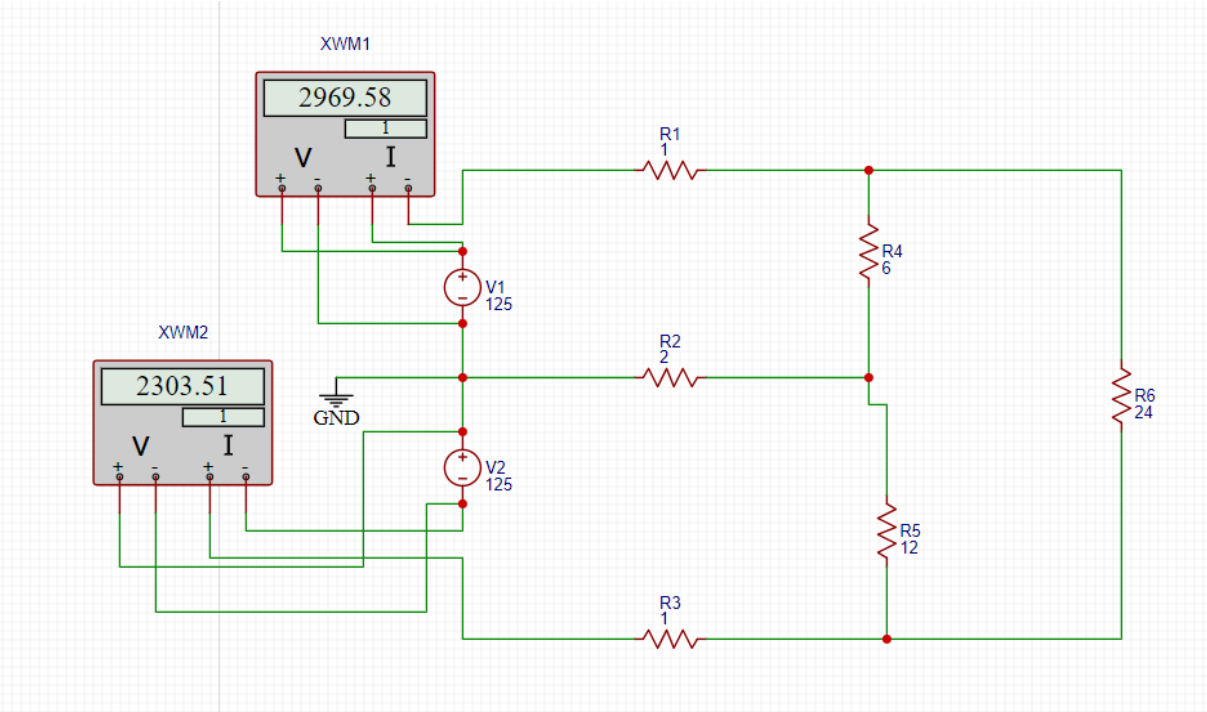
4.12



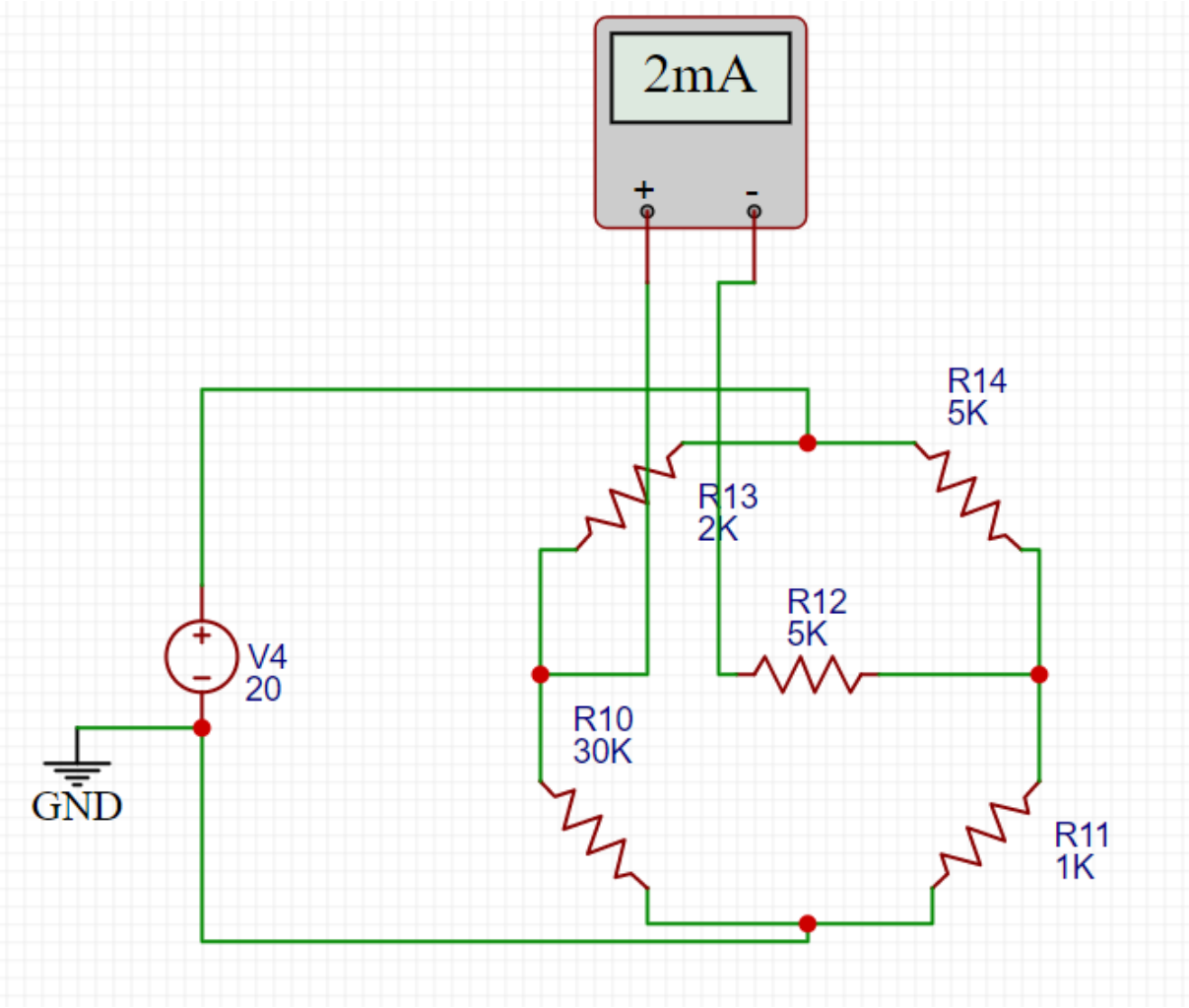
4.15-a


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

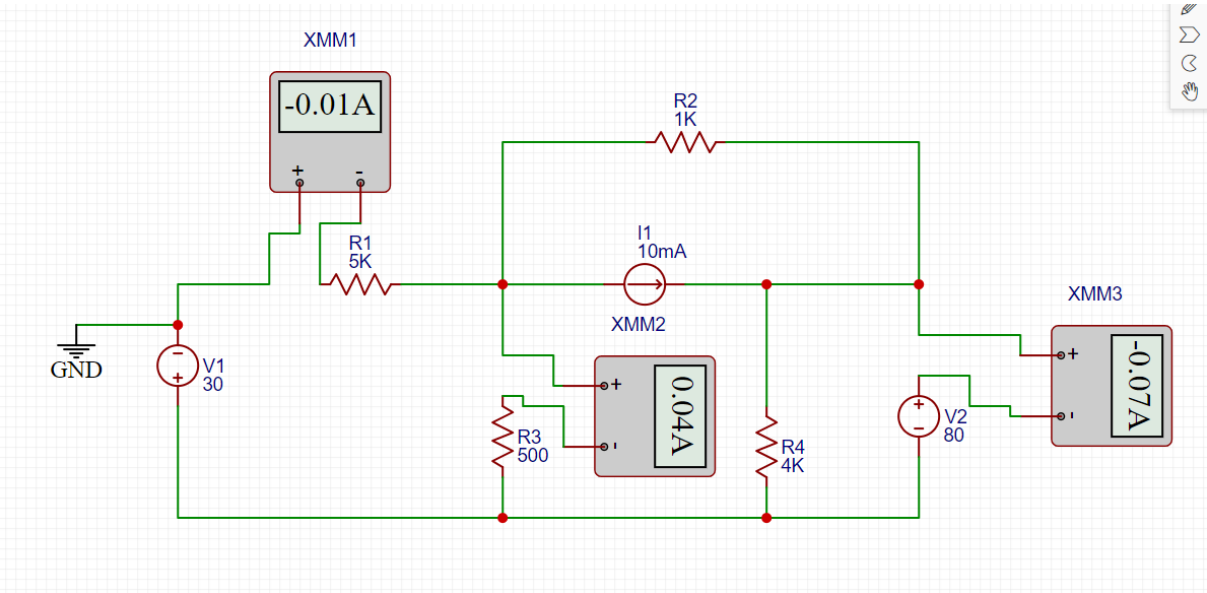
4.15-b


XWM1
2969.58
1
V
I
R1
1
R4
6
V1
125
XWM2
2303.51
1
V
I
R2
2
R6
24
GND
V2
125
R5
12
R3
1

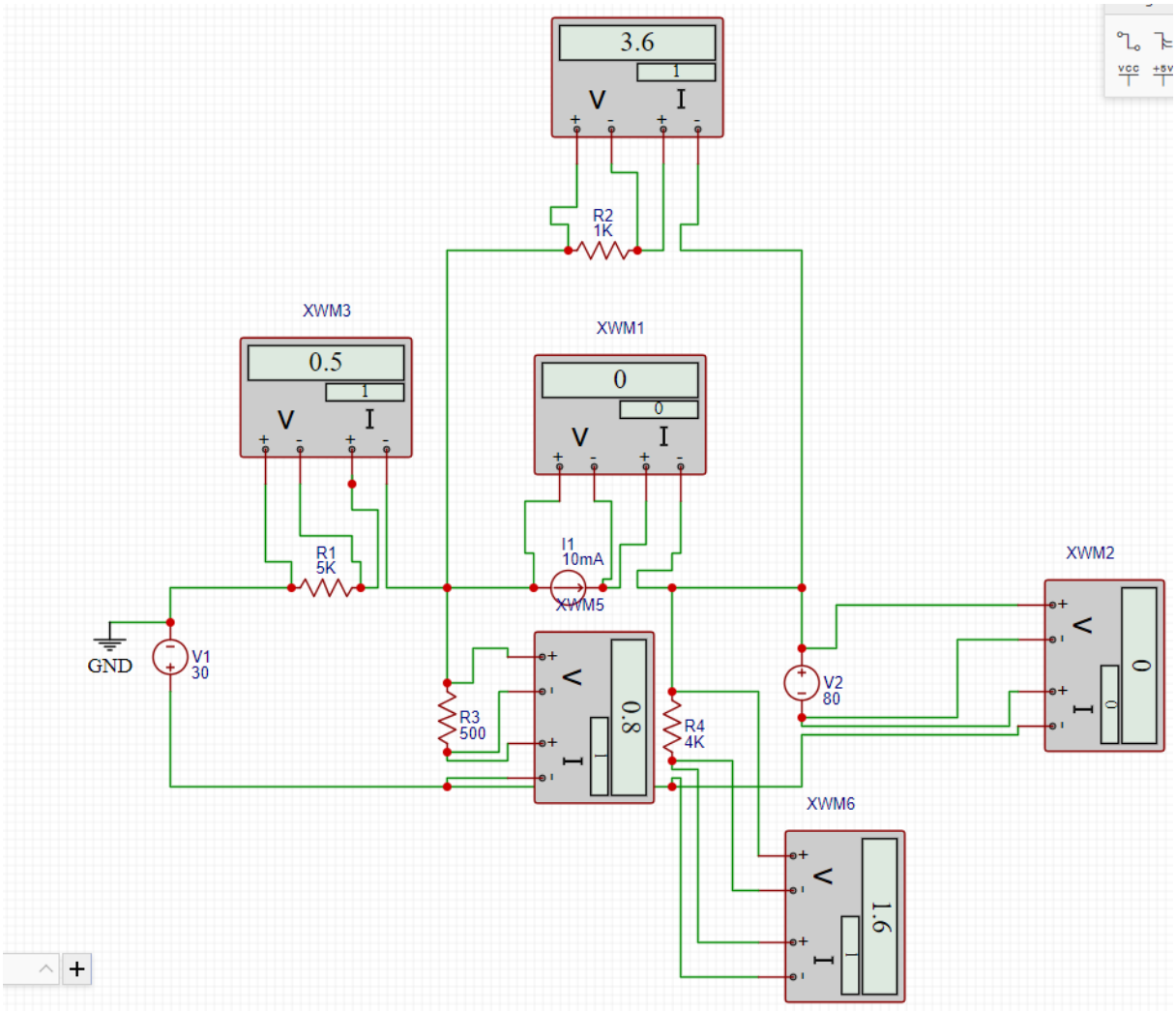
4.24


2mA
+
-
R14
5K
R13
2K
R12
5K
R10
30K
R11
1K
V4
20
GND

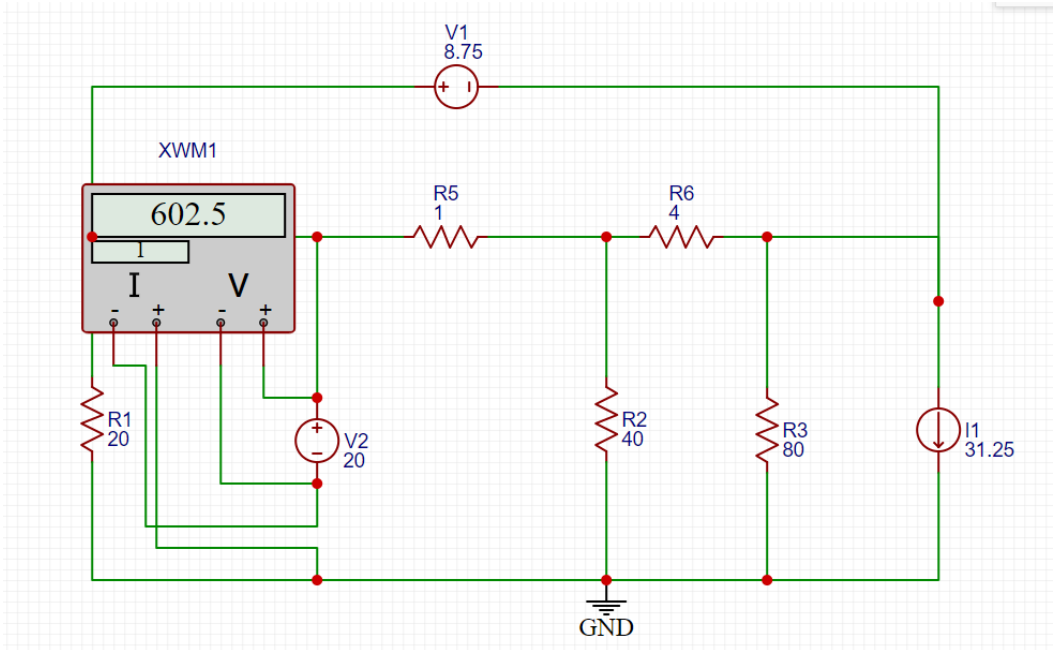
4.27


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

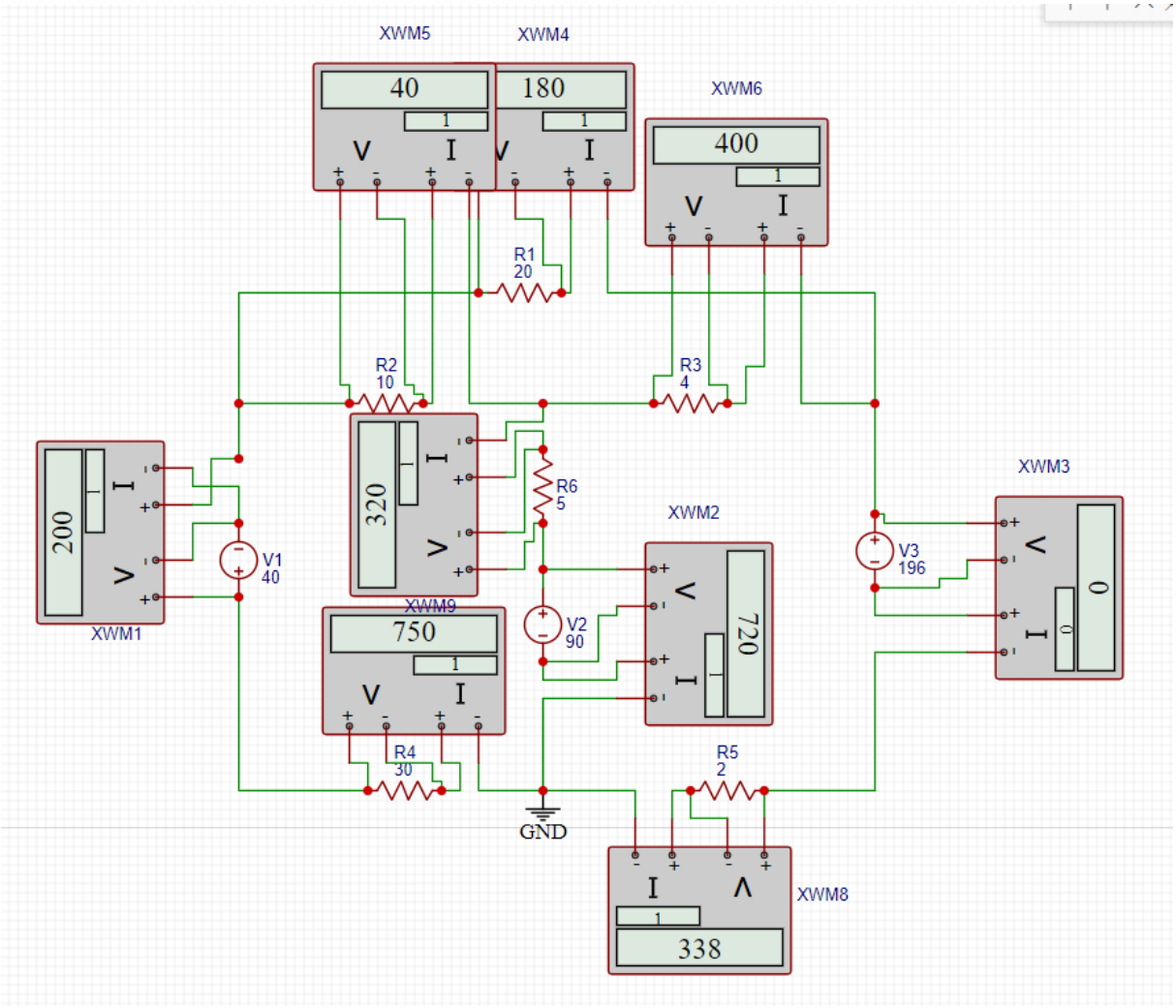
4.27.b


3.6
1
V
I
R2
1K
XWM3
0.5
XWM1
0
R1
5K
I1
10mA
XWM5
XWM2
GND
V1
30
R3
500
0.8
R4
4K
V2
80
XWM6
1.6

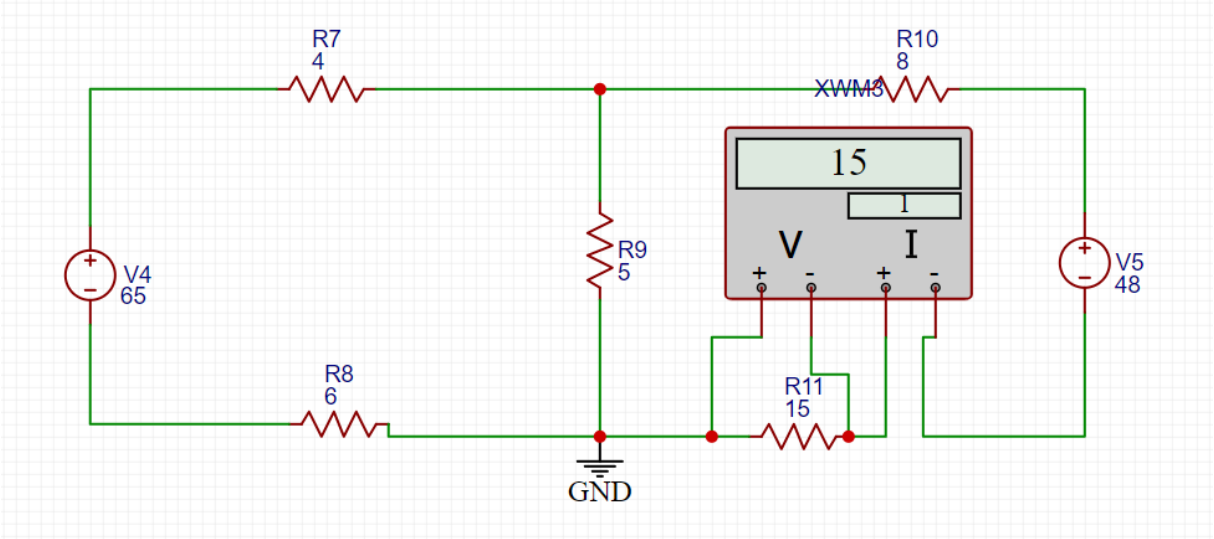
4.30


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

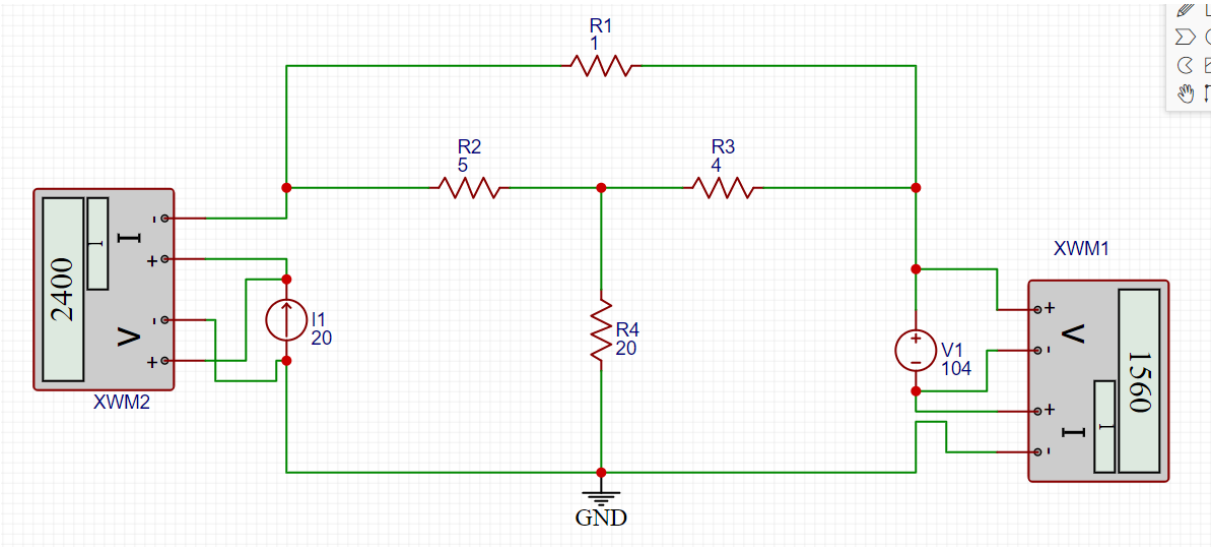
4.36


XWM5
XWM4
40
180
XWM6
400
R1
20
R2
10
R3
4
320
R6
5
XWM3
200
V1
40
XWM1
XWM2
V3
196
XWM9
750
V2
90
720
0
R4
30
R5
2
GND
XWM8
338

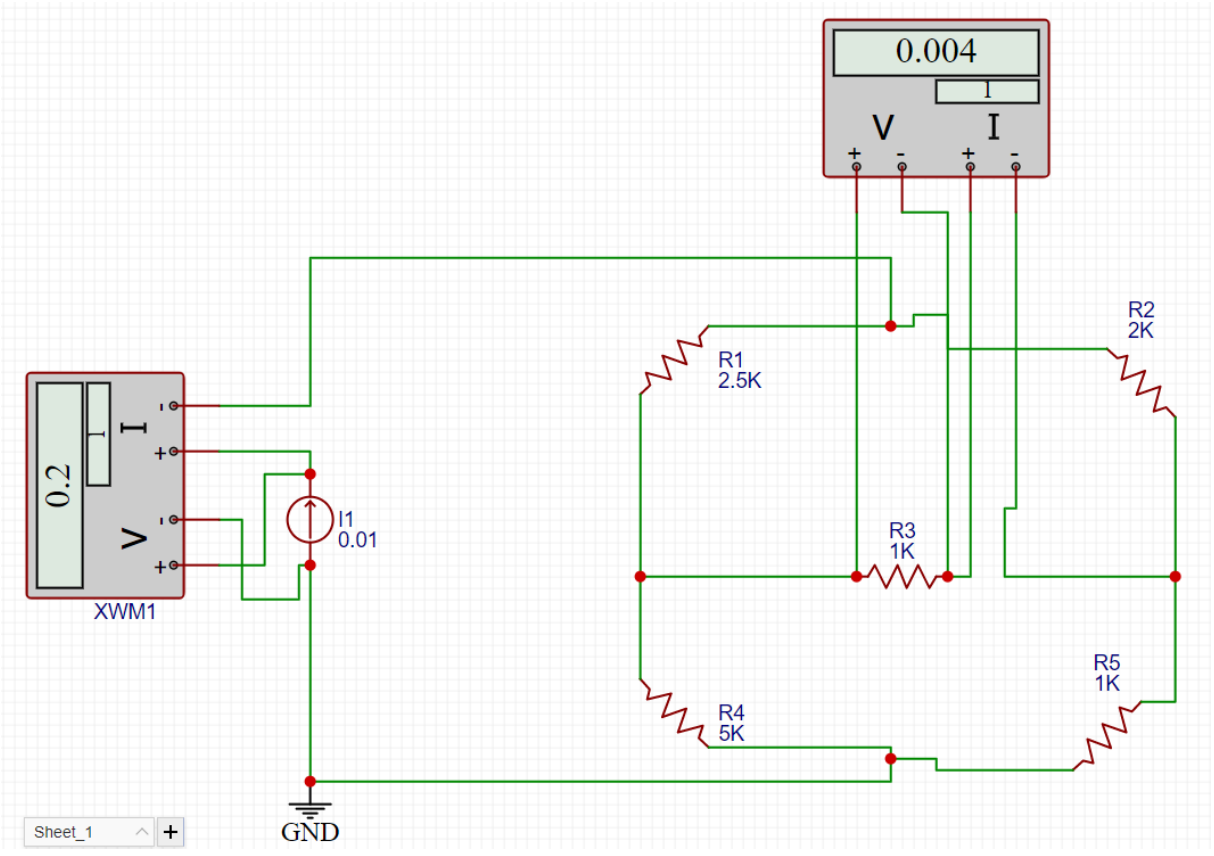
4.39


R7
4
R10
8
XWM3
15
R9
5
V4
65
V5
48
R8
6
R11
15
GND

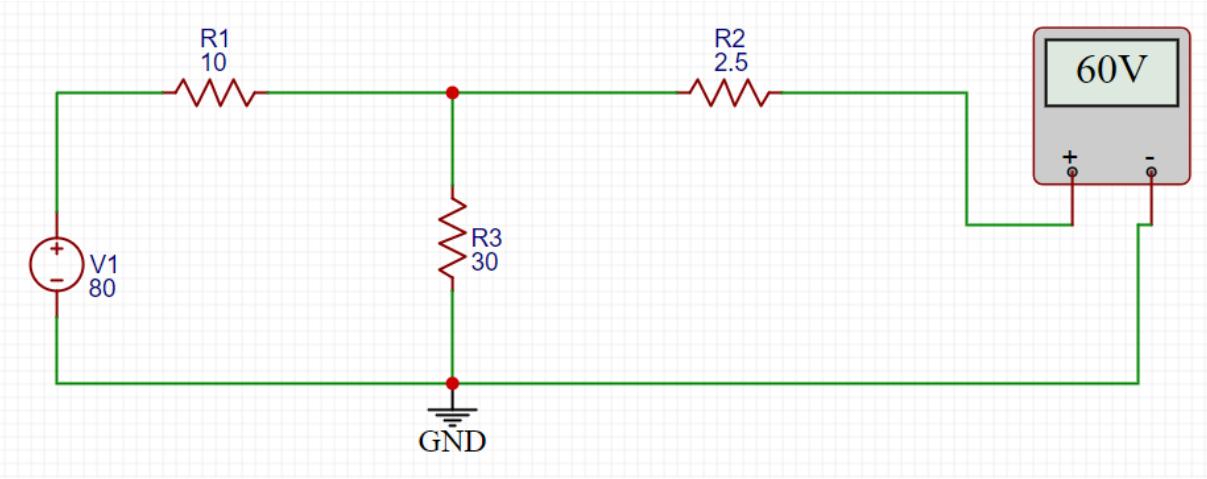
4.46


R1
1
R2
5
R3
4
R4
20
I1
20
V1
104
2400
1560
XWM1
XWM2
GND

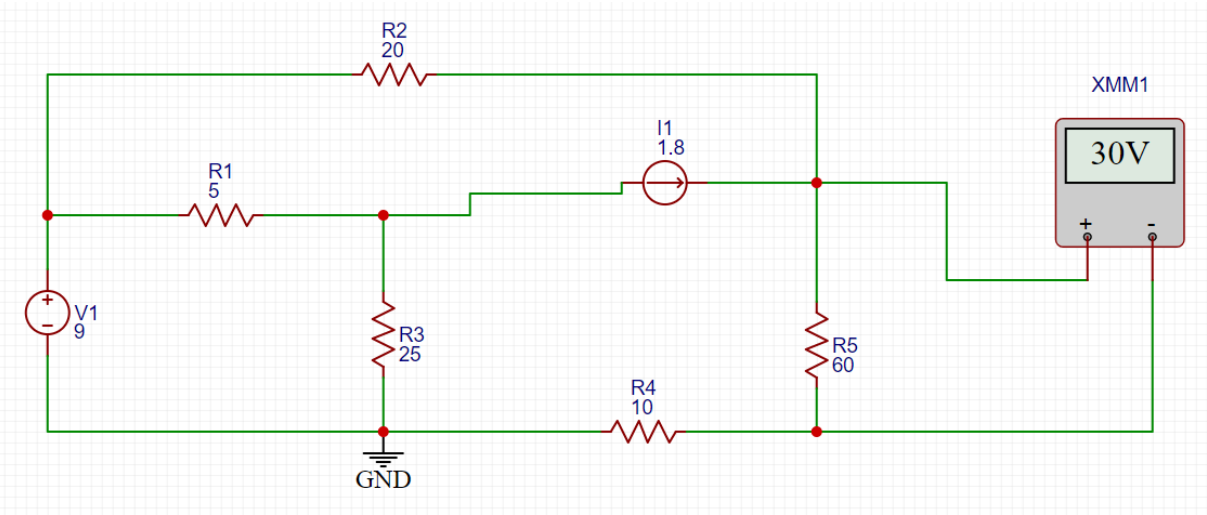
4.54


0.004
R1
2.5K
R2
2K
R3
1K
R4
5K
R5
1K
I1
0.01
0.2
XWM1
GND
Sheet_1

4.64



4.78



Barış Ayyıldız 1901042252