CSE 231

- Homework 1 -

6.11.2020

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3.1

3.1 a) Show that the solution of the circuit in Fig. 3.9 (see Example 3.1) satisfies Kirchhoff's current law at junctions x and y.

b) Show that the solution of the circuit in Fig. 3.9 satisfies Kirchhoff's voltage law around every closed loop.

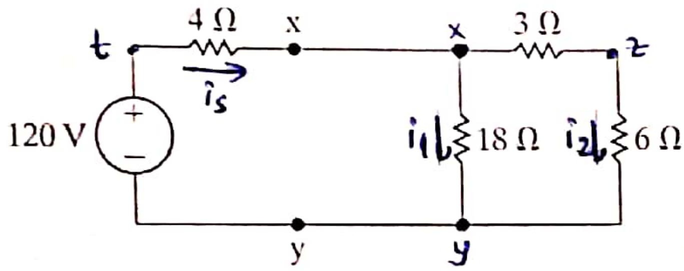


Figure 3.9 ▲ The circuit for Example 3.1.

Currents was found other example

$i_s = 12\ A,\ i_1 = 4\ A,\ i_2 = 8\ A$

a) For node x:

$i_s = i_1 + i_2$

$12 = 4 + 8$

(Node 'a giren akımlar çıkanlara eşit)

For node y:

$i_s = i_1 + i_2$

$12 = 4 + 8$

b) loop txyt

$-120 + 48 + 72 = 0$

loop xzyx

$-72 + 24 + 48 = 0$

loop txzyt

$-120 + 48 + 24 + 48 = 0$

3.2

3.2 a) Find the power dissipated in each resistor in the circuit shown in Fig. 3.9.

b) Find the power delivered by the 120 V source.

c) Show that the power delivered equals the power dissipated.

Power = $\boxed{P = i^2 \cdot R = V \cdot i}$

a) $P_{4\Omega} = 12^2 \cdot 4 = 576\ W$

$P_{3\Omega} = 8^2 \cdot 3 = 192\ W$

$P_{18\Omega} = 4^2 \cdot 18 = 288\ W$

$P_{6\Omega} = 8^2 \cdot 6 = 384\ W$

b) $P_{120V} = 120 \cdot i = 120 \cdot 12 = 1440\ W$

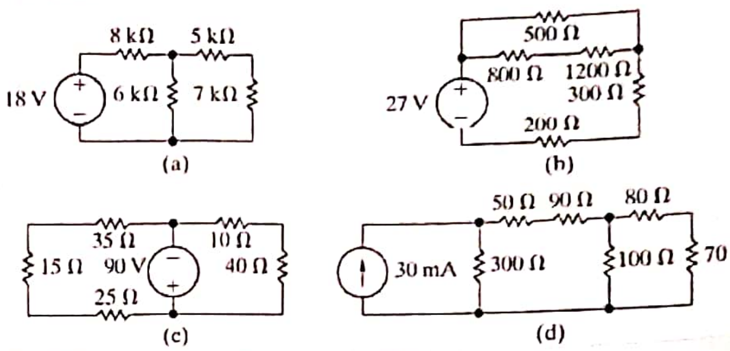
c) $1440 = 576 + 192 + 288 + 384$

$1440 = 1440$ ✓

3.3

3.3 For each of the circuits shown in Fig. P3.3,
a) identify the resistors connected in series,
b) simplify the circuit by replacing the series-connected resistors with equivalent resistors.

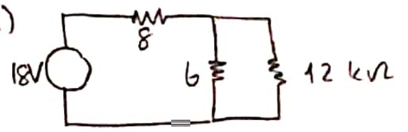
Figure P3.3



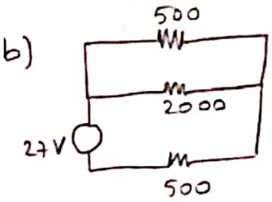
a) circuit
- a) 5 kΩ and 7 kΩ in series
- b) 800 Ω and 1200 Ω || and 300 Ω 200 Ω series
- c) 35 Ω, 15 Ω and 25 Ω ||
- d) 50 Ω, 90 Ω series
  80 Ω, 70 Ω series

b)

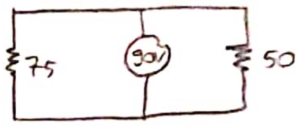
a)



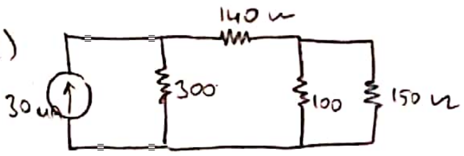
b)



c)

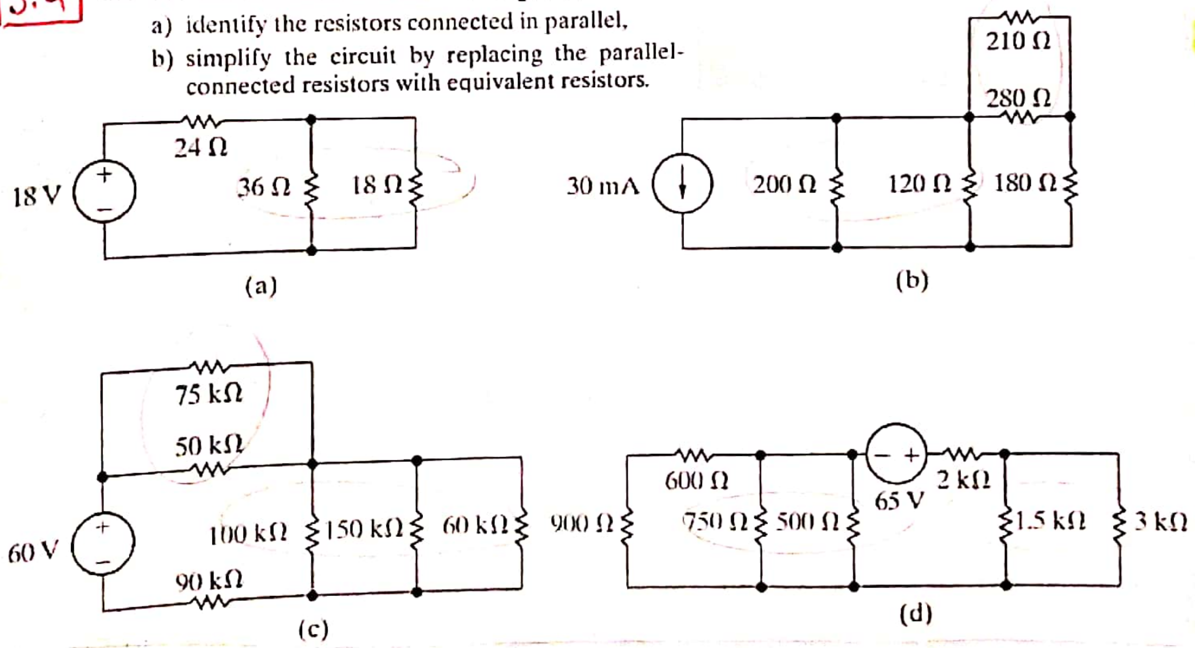


d)



3.4

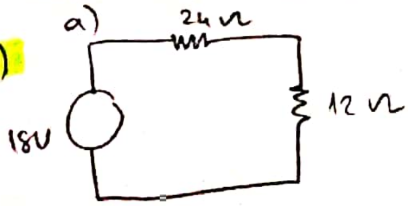
3.4 For each of the circuits shown in Fig. P3.4,
a) identify the resistors connected in parallel,
b) simplify the circuit by replacing the parallel-connected resistors with equivalent resistors.



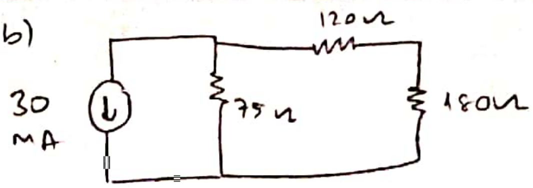
a) circuit
- a) 36 Ω || 18 Ω
- b) 200 Ω || 120 Ω
  210 Ω || 280 Ω
- c) 75 kΩ || 50 kΩ
  100 || 150 || 60
- d) 750 Ω || 500 Ω
  1.5 kΩ || 3 kΩ

b)

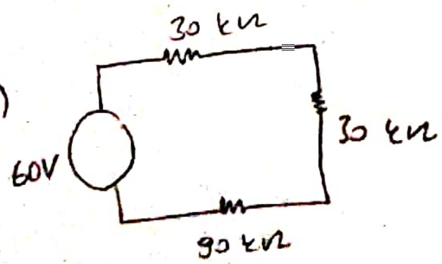
a)



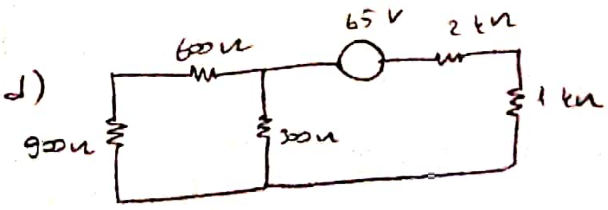
b)



c)



d)



3.5

3.5 For each of the circuits shown in Fig. P3.3,

a) find the equivalent resistance seen by the source.

b) find the power developed by the source.

a) Circuit a → $R_{eq} = \left[(7000+5000) \parallel 6000\right] + 8000 = 4000 + 8000 = 12\ k\Omega$ //

Circuit b → $R_{eq} = \left[(800+1200) \parallel 500\right] + 300 + 200 = (400+300+200)$

$= 900\ \Omega$ //

Circuit c → $R_{eq} = (35+15+25) \parallel (10+40) = 30\ \Omega$ //

Circuit d → $R_{eq} = \left[\left[(70+80) \parallel 100\right] + (50+90)\right] \parallel 300 = (60+50+90) \parallel 300$

$= 120\ \Omega$ //

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

Circuit a → $P = \frac{18^2}{12000} = 0.027\ W$ //

Circuit b → $P = \frac{27^2}{900} = 0.81\ W$ //

Circuit c → $P = \frac{90^2}{30} = 270\ W$ //

Circuit d → $P = (0.03)^2 \cdot 120 = 0.108\ W$ //

3.8

3.8 Find the equivalent resistance R_{ab} for each of the circuits in Fig. P3.8.

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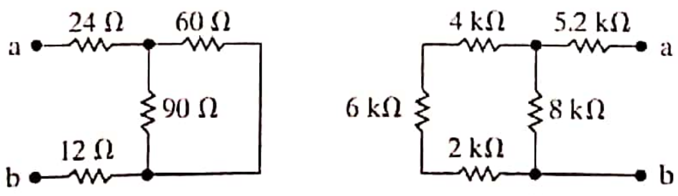
Figure P3.8



(a) (b)

Circuit a

$R_{ab} = 24 + (60 \parallel 90) + 12$

$= 24 + 36 + 12 = 72\ \Omega$ //

Circuit b

$R_{ab} = \left[(4k + 6k + 2k) \parallel 8k\right] + 5.2k$

$= (12k \parallel 8k) + 5.2k$

$= 10\ k\Omega$ //

Circuit c

$R_{ab} = 1200 \parallel 720 \parallel (320 + 480) = 288\ \Omega$ //

3.13

3.13 In the voltage-divider circuit shown in Fig. P3.13, the no-load value of v_o is 4 V. When the load resistance R_L is attached across the terminals a and b, v_o drops to 3 V. Find R_L.

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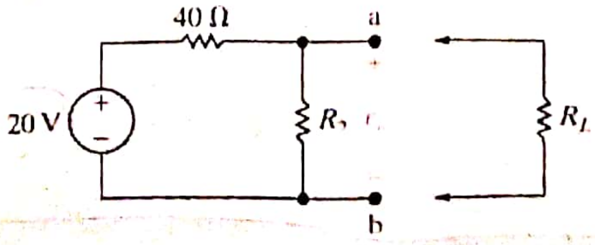
Figure P3.13



$V_o \to 4V,\ 3V$

$\frac{20 \cdot R_2}{40 + R_{eq}} = 4V \to R_2 = 10\ \Omega$

$\frac{20 \cdot R_{eq}}{40 + R_{eq}} = 3V \to R_{eq} = \frac{120}{17}\ \Omega$

$\frac{120}{17} = R_2 \parallel R_L$

$\frac{120}{17} = 10\ \Omega \parallel R_L \to R_L = 24\ \Omega$

3.17

3.17 For the current divider circuit in Fig. P3.17 calculate

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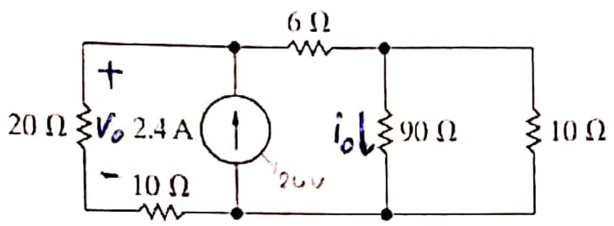
a) i_o and v_o.

b) the power dissipated in the 6 Ω resistor.

c) the power developed by the current source.

Figure P3.17



b) $P_{6\Omega} = \frac{V^2}{R} = \frac{(24-14.4)^2}{6}$

$= 15.3\ W$ //

c) $P_{2.4A} = V\cdot i = (2.4)\cdot 24$

$= -57.6\ W$

a) First find $R_{eq} = (10+20) \parallel [6 + (90 \parallel 10)]$

$R_{eq} = 10\ \Omega$

$V = i\cdot R \Rightarrow V_{2.4A} = 2.4 \cdot 10 = 24\ V$

$V_{20\Omega} = \frac{20}{20+10} \cdot 24 = \boxed{16V = V_o}$ //

$V_{90\Omega} = \frac{90\cdot 10/100}{6 + 90\cdot 10/100} \cdot 24 = \frac{9}{15}\cdot 24 = 14.4\ V \rightarrow i_o = \frac{14.4}{90\Omega} = \boxed{0.16\ A}$ //

3.18

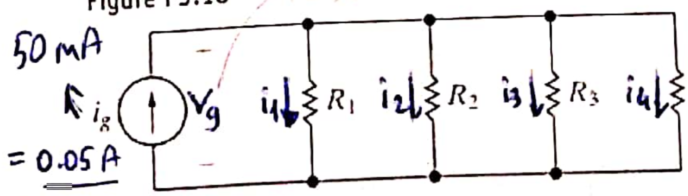
3.18 Specify the resistors in the current divider circuit in Fig. P3.18 to meet the following design criteria:

DESIGN PROBLEM

$i_g = 50$ mA; $v_g = 25$ V; $i_1 = 0.6i_2$;
$i_3 = 2i_2$; and $i_4 = 4i_1$.

Figure P3.18

25V



$i_g = i_1 + i_2 + i_3 + i_4$

$0.05 = 0.6i_2 + i_2 + 2i_2 + 4i_1$

$0.05 = 0.6i_2 + 3i_2 + 4\cdot 0.6i_2$

$0.05 = 6i_2 \rightarrow i_2 = 0.0083\ A$

$i_2 = 8.3\ mA$

$i_1 = 0.6i_2 = 0.005\ A$

$i_3 = 2i_2 = 0.0166\ A$

$i_4 = 4i_1 = 0.02\ A$

25 V affects all

$R_1 = \frac{V}{i} = \frac{25}{i_1} = \frac{25}{0.005} = 5000\ \Omega$

$R_2 = \frac{25}{i_2} = \frac{25}{0.0083} = 3000\ \Omega$

$R_3 = \frac{25}{i_3} = \frac{25}{0.0166} = 1500\ \Omega$

$R_4 = \frac{25}{i_4} = \frac{25}{0.02} = 1250\ \Omega$

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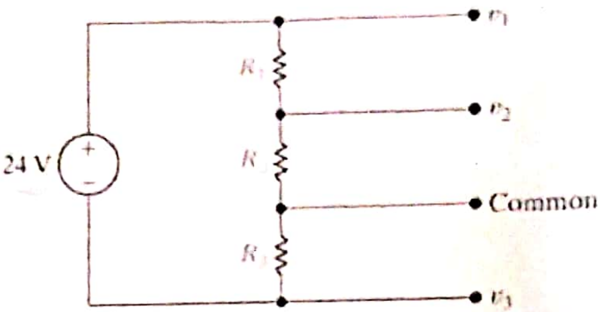
$\boxed{3.19}$

3.19 DESIGN PROBLEM There is often a need to produce more than one voltage using a voltage divider. For example, the memory components of many personal computers require voltages of −12 V, 5 V, and +12 V, all with respect to a common reference terminal. Select the values of R_1, R_2, and R_3 in the circuit in Fig. P3.19 to meet the following design requirements:

a) The total power supplied to the divider circuit by the 24 V source is 80 W when the divider is unloaded.

b) The three voltages, all measured with respect to the common reference terminal, are $v_1 = 12$ V, $v_2 = 5$ V, and $v_3 = -12$ V.

Figure P3.19



$$\text{Power} = \frac{V^2}{R} = 80 = \frac{24^2}{R_1+R_2+R_3} \longrightarrow R_1+R_2+R_3 = 7.2\ \Omega$$

$$\text{Voltage division} \rightarrow 24 \cdot \frac{(R_1+R_2)}{R_1+R_2+R_3} = 12 \longrightarrow R_1+R_2 = 3.6\ \Omega$$

$$\longrightarrow 2R_1+2R_2 = R_1+R_2+R_3$$

$$R_1+R_2 = \boxed{R_3 = 3.6\,\Omega}$$

$$\text{Voltage division} \rightarrow 24 \cdot \frac{R_2}{R_1+R_2+R_3} = 5 \longrightarrow R_2 = 36/24 = \boxed{1.5\ \Omega}$$

$$R_1 = 3.6 - 1.5 = \boxed{2.1\ \Omega}$$

$\boxed{3.22}$

3.22 PSPICE MULTISIM a) Show that the current in the kth branch of the circuit in Fig. P3.22(a) is equal to the source current i_g times the conductance of the kth branch divided by the sum of the conductances, that is,

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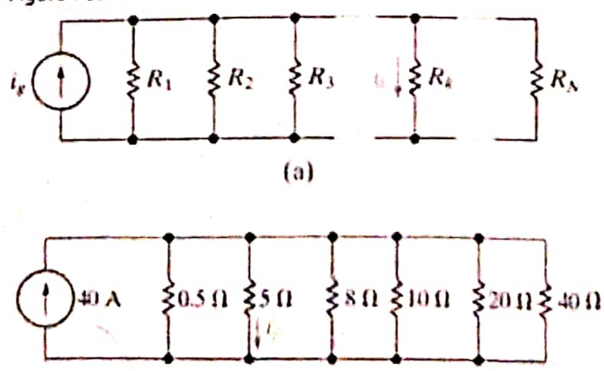
$$i_k = \frac{i_g G_k}{G_1 + G_2 + G_3 + \cdots + G_k + \cdots + G_N}.$$

$G = \frac{1}{R} = \frac{1}{\Omega}$ (siemen)

b) Use the result derived in (a) to calculate the current in the 5 Ω resistor in the circuit in Fig. P3.22(b).

Figure P3.22



(a)

(b)

a) $V = i \cdot R \qquad G = \frac{1}{R} \rightarrow R = \frac{1}{G}$

$$i = \frac{V}{R} = \frac{V}{\frac{1}{G}} = \boxed{V \cdot G}$$

Assume voltage be V

$$i_g = V \cdot G_1 + V \cdot G_2 + \cdots + V \cdot G_N$$

$$i_g = V \cdot (G_1 + G_2 + G_3 + \cdots + G_N)$$

Current on the k^{th} branch is

$$i_k = V \cdot G_k \rightarrow V = \frac{i_k}{G_k}$$

$$i_g = \frac{i_k}{G_k} \cdot (G_1 + G_2 + \cdots + G_N)$$

$$i_k = \frac{i_g \cdot G_k}{(G_1 + G_2 + \cdots + G_N)}$$

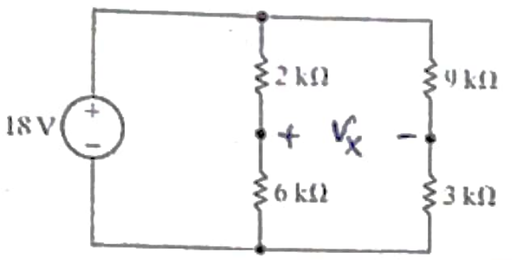
b) $$i_{5\Omega} = \frac{40 \cdot \left(\frac{1}{5}\right)}{\frac{1}{0.5} + \frac{1}{5} + \frac{1}{8} + \frac{1}{10} + \frac{1}{20} + \frac{1}{40}} = \underline{3.2\ \text{A}}$$

3.28

3.28 a) Find the voltage v_x in the circuit in Fig. P3.28 using voltage and/or current division.

b) Replace the 18 V source with a general voltage source equal to V_s. Assume V_s is positive at the upper terminal. Find v_x as a function of V_s.

Figure P3.28



a) $V_{2k} = \frac{2}{2+6} \cdot 18 = 4.5\ V$

$V_{9k} = \frac{9}{9+3} \cdot 18 = 13.5\ V$

$V_x = 13.5 - 4.5 = 9\ V$

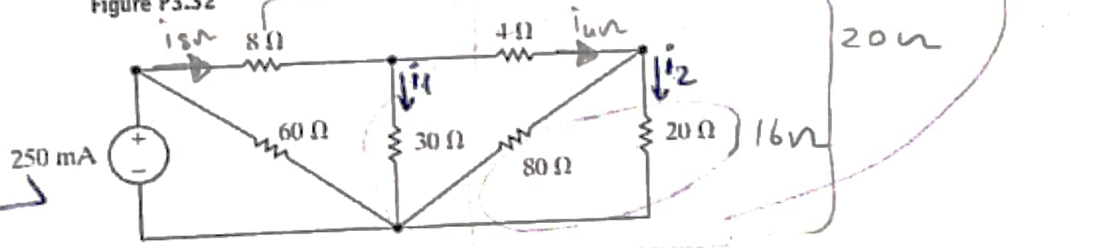
b) $V_{2k} = \frac{2}{8} V_s \qquad V_{9k} = \frac{9}{12} V_s$

$V_x = \frac{9}{12} V_s - \frac{2}{8} V_s = \frac{2 V_s}{4} = \frac{V_s}{2}$

3.32

3.32 For the circuit in Fig. P3.32, calculate i_1 and i_2 using current division.

Figure P3.32



$i_{8\Omega} = \frac{60 \parallel 20}{20} \cdot (0.25) = 0.1875\ A$

$i_1 = \frac{30 \parallel 20}{30} \cdot i_{8\Omega} = 0.075\ A$

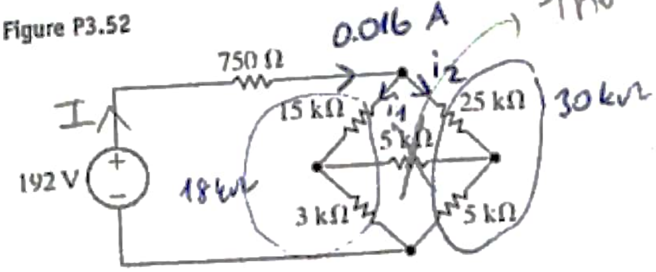
$i_{4\Omega} = \frac{30 \parallel 20}{20} \cdot i_{8\Omega} = 0.1125\ A$

$i_2 = \frac{80 \parallel 20}{20} \cdot i_{4\Omega} = 0.09\ A$

3.52

3.52 Find the power dissipated in the 3 kΩ resistor in the circuit in Fig. P3.52.

Figure P3.52



There is no current through

15.5 = 25.3 ✓

$R_{eq} = \left[(25k + 5k) \parallel (3k + 15k) \right] + 750$

$R_{eq} = 11.25\ k\Omega + 750\ \Omega$
$= 12\ k\Omega = 12000\ \Omega$

$V = I \cdot R$
$192 = I \cdot 12000$
$\boxed{I = 0.016\ A}$

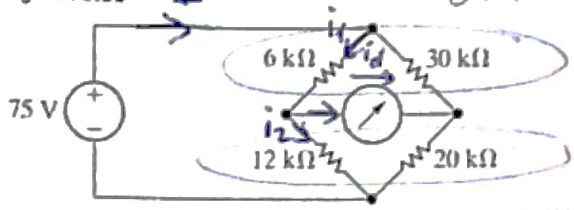
$i_1 = \frac{11250\ \Omega}{18000\ \Omega} \cdot (0.016) \rightarrow i_1 = 0.01\ A$

$P_{3k\Omega} = i^2 \cdot R = (0.01)^2 \cdot 3000 = 0.3\ W$

3.53

3.53 Find the detector current i_d in the unbalanced bridge in Fig. P3.53 if the voltage drop across the detector is negligible.

Figure P3.53



$6k \parallel 30k \rightarrow 5k\Omega$

$12k \parallel 20k \rightarrow 7.5k\Omega$

$R_{eq} = 12500\Omega$

75V → 5k → 30V; 7.5k → 45V

$I = \frac{75}{12500} \rightarrow I = 0.006$ A

$\boxed{i_1 = i_d + i_2}$

$i_1 = \frac{V}{R} = \frac{30V}{6000} = 0.005$ A

$i_2 = \frac{V}{R} = \frac{45V}{12000} = 0.00375$ A

$i_d = i_1 - i_2$
$= 0.005 - 0.00375$
$= 0.00125$ A

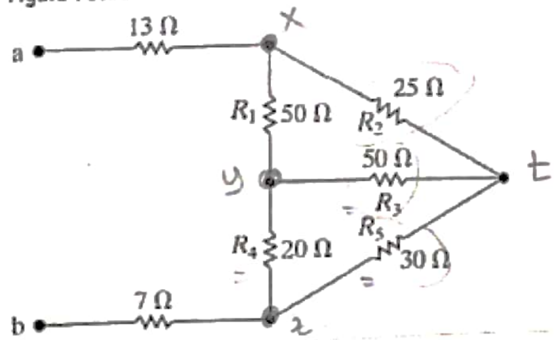
3.58

3.58 a) Find the equivalent resistance R_{ab} in the circuit in Fig. P3.58 by using a Y-to-Δ transformation involving resistors R_2, R_3, and R_5.

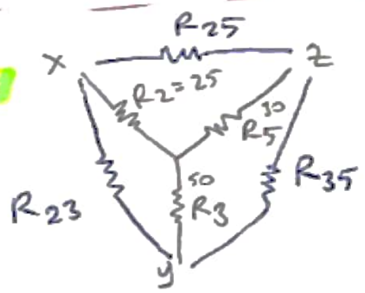
b) Repeat (a) using a Δ-to-Y transformation involving resistors R_3, R_4, and R_5.

c) Give two additional Δ-to-Y or Y-to-Δ transformations that could be used to find R_{ab}.

Figure P3.58



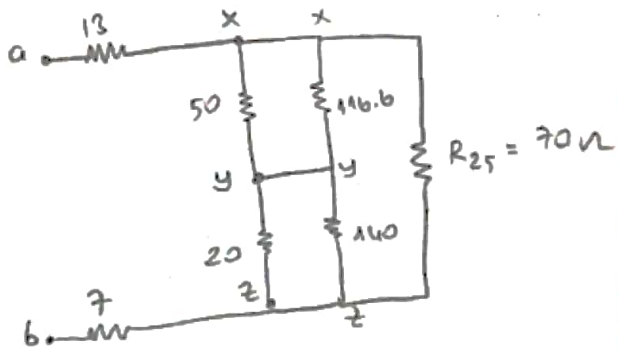
a)



$R_{23} = \frac{25 \cdot 50 + 25 \cdot 30 + 50 \cdot 30}{30} = 116.6\Omega$

$R_{25} = \frac{25 \cdot 50 + 25 \cdot 30 + 50 \cdot 30}{50} = 70\Omega$

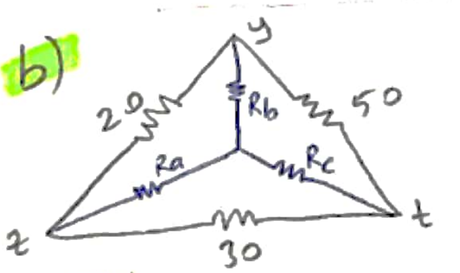
$R_{35} = \frac{25 \cdot 50 + 25 \cdot 30 + 50 \cdot 30}{25} = 140\Omega$



$R_{eq} = 70 \parallel [(50 \parallel 116.6) + (20 \parallel 140)] + 13 + 7$

$R_{eq} = 50\Omega$

b)

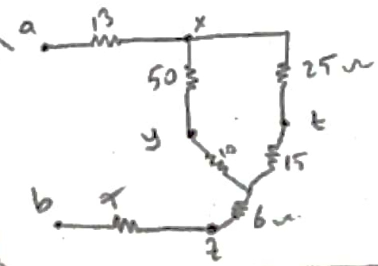


$R_a = \frac{20 \cdot 30}{20+30+50} = 6\Omega$

$R_b = \frac{20 \cdot 50}{20+30+50} = 10\Omega$

$R_c = \frac{30 \cdot 50}{20+30+50} = 15\Omega$

$R_{eq} = (50+10) \parallel (25+5) + 6 + 13 + 7$
$= 50\Omega$



c) Δ-Y → R_1, R_3, R_2

Y-Δ → R_1, R_4, R_3

3.62

3.62 Find i_o and the power dissipated in the 140 Ω resistor in the circuit in Fig. P3.62.

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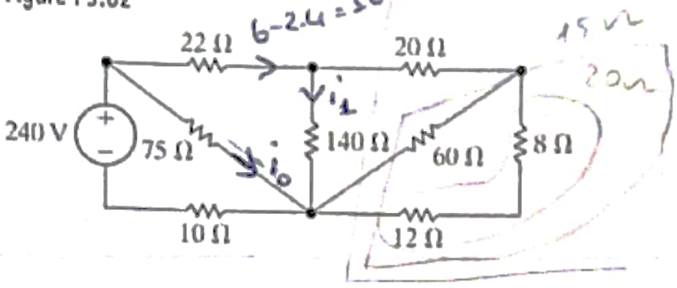
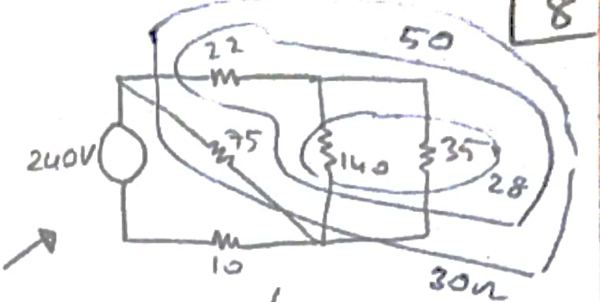
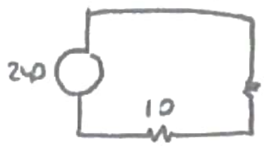
Figure P3.62

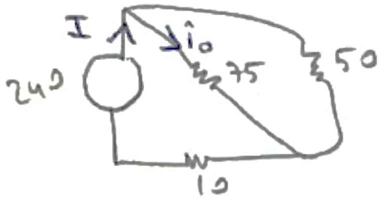






$\rightarrow R_{eq} = 40\Omega$

$V = I \cdot R \rightarrow 240 = I \cdot 40 \rightarrow I = 6A$



$i_o = \dfrac{50 \cdot 6}{(50+75)} = 2.4\ A$

$i_1 = \dfrac{(3.6) \cdot 35}{(35+140)} = 0.72\ A$

$P_{140\Omega} = i^2 \cdot R = (0.72)^2 \cdot 140 = 72.57\ W$

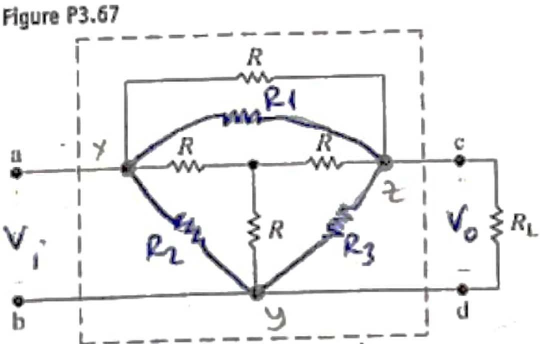
3.67

3.67 a) The fixed-attenuator pad shown in Fig. P3.67 is called a *bridged tee*. Use a Y-to-Δ transformation to show that $R_{ab} = R_L$ if $R = R_L$.

DESIGN PROBLEM

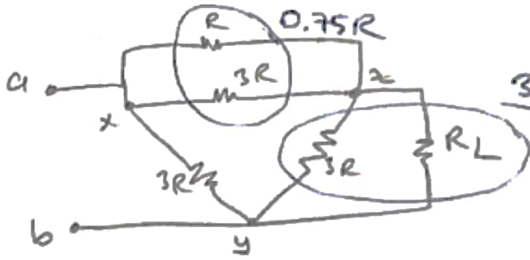
b) Show that when $R = R_L$, the voltage ratio v_o/v_i equals 0.50.

Figure P3.67

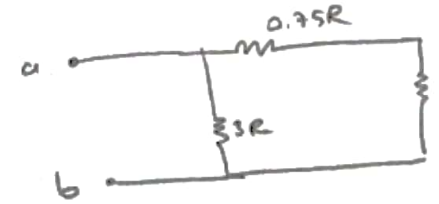


Fixed-attenuator pad

a) $R_1 = R_2 = R_3 = \dfrac{R \cdot R + R \cdot R + R \cdot R}{R} = 3R$



$\dfrac{3R \cdot R_L}{3R + R_L}$



$\dfrac{3R \cdot R_L}{3R + R_L}$

$R_{ab} = 3R \parallel \left(0.75R + \dfrac{3R \cdot R_L}{3R + R_L}\right)$

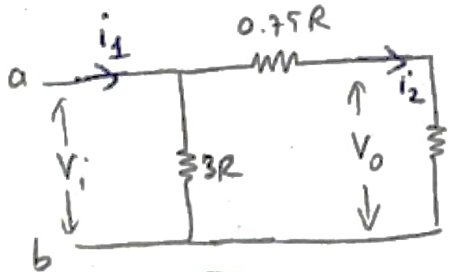
$R_{ab} = \dfrac{3R \cdot \left(\dfrac{2,25R^2 + 3,75RR_L}{3R + R_L}\right)}{3R + \left(\dfrac{2,25R^2 + 3,75R \cdot R_L}{3R + R_L}\right)}$

$R_{ab} = \dfrac{3R_L \cdot 8R_L}{24 R_L} = R_L$

if $R_L = R$

$R_{ab} = R_L$ ✓

b)



$\dfrac{3R \cdot R_L}{3R + R_L}$

if $R = R_L$

$0.75R$

$i_2 = \dfrac{i_1 \cdot 3\cancel{R}}{4.5\cancel{R}} = \dfrac{i_1}{1.5}$

$i_1 = \dfrac{V_i}{R_{L,eq}}$

$V_o = i_2 \cdot 0.75R = \dfrac{i_1}{1.5} \cdot 0.75R$

$\dfrac{V_o}{V_i} = \dfrac{\dfrac{\cancel{i_1} \cdot 0.75\cancel{R}}{1.5}}{\cancel{i_1} \cdot \cancel{R}} = \dfrac{1}{2} = 0.5$

3.73

3.73 A resistive touch screen has 5 V applied to the grid in the x-direction and in the y-direction. The screen has 480 pixels in the x-direction and 800 pixels in

$V_x = 1 \quad V_y = 3.75$

the y-direction. When the screen is touched, the voltage in the x-grid is 1 V and the voltage in the y-grid is 3.75 V.

a) Calculate the values of α and β.

a) Calculate the x- and y-coordinates of the pixel at the point where the screen was touched.

a) 3.72. question formula ⇒ $V_x = \alpha V_s$, $V_y = \beta V_s$ ⇝ $\alpha = \frac{1}{5} = 0.2$, $\beta = \frac{3.75}{5} = 0.75$

b) 3.72. question formula ⇒ $x = P_x(1-\alpha)$, $y = P_y(1-\beta)$ ⇝ $x = 480 \cdot (1-0.2) = 384$, $y = 800\,(1-0.75) = 200$

3.74

3.74 A resistive touch screen has 640 pixels in the x-direction and 1024 pixels in the y-direction. The resistive grid has 8 V applied in both the x- and y-directions. The pixel coordinates at the touch point are (480, 192). Calculate the voltages V_x and V_y.

$V_s = 8$ $\quad P_x = 640$ $\quad P_y = 1024$

$x = 480$ $\quad y = 192$

3.72. question formula ⇒

$$x = P_x\,(1-\alpha)$$
$$y = P_y\,(1-\beta)$$
$$V_x = \alpha V_s$$
$$V_y = \beta V_s$$

$480 = 640 \cdot (1-\alpha)$

$\alpha = 0.25$

$192 = 1024\,(1-\beta)$

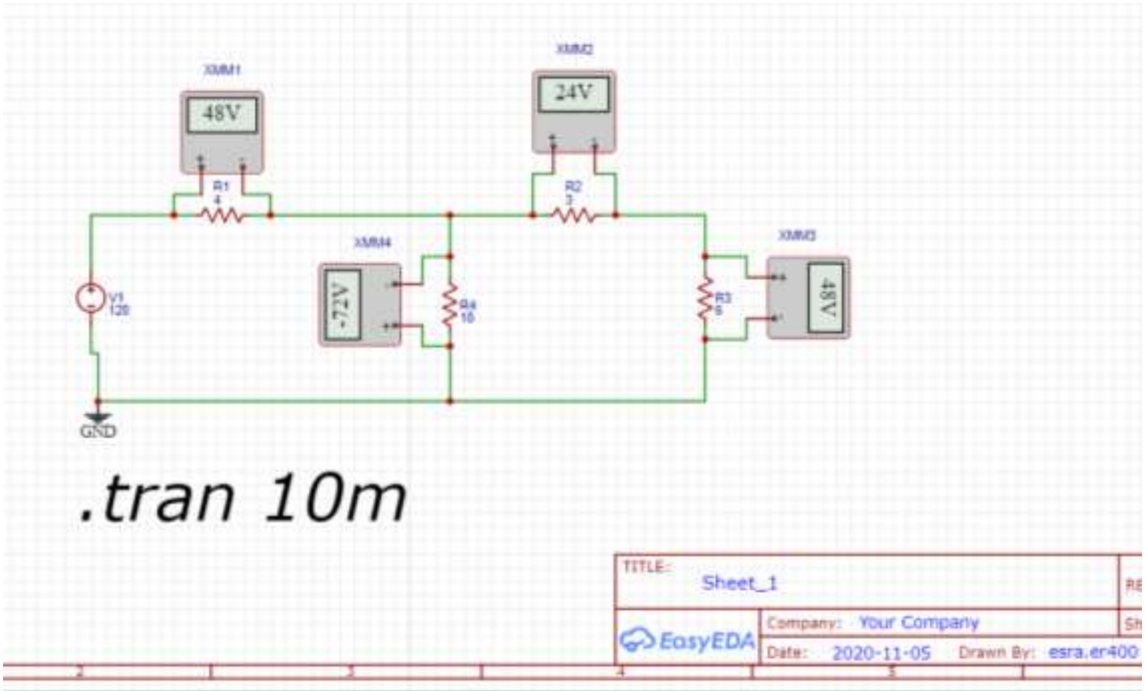
$\beta = 0.8125$

$V_x = \alpha V_s = 0.25 \cdot 8 = 2\,V$

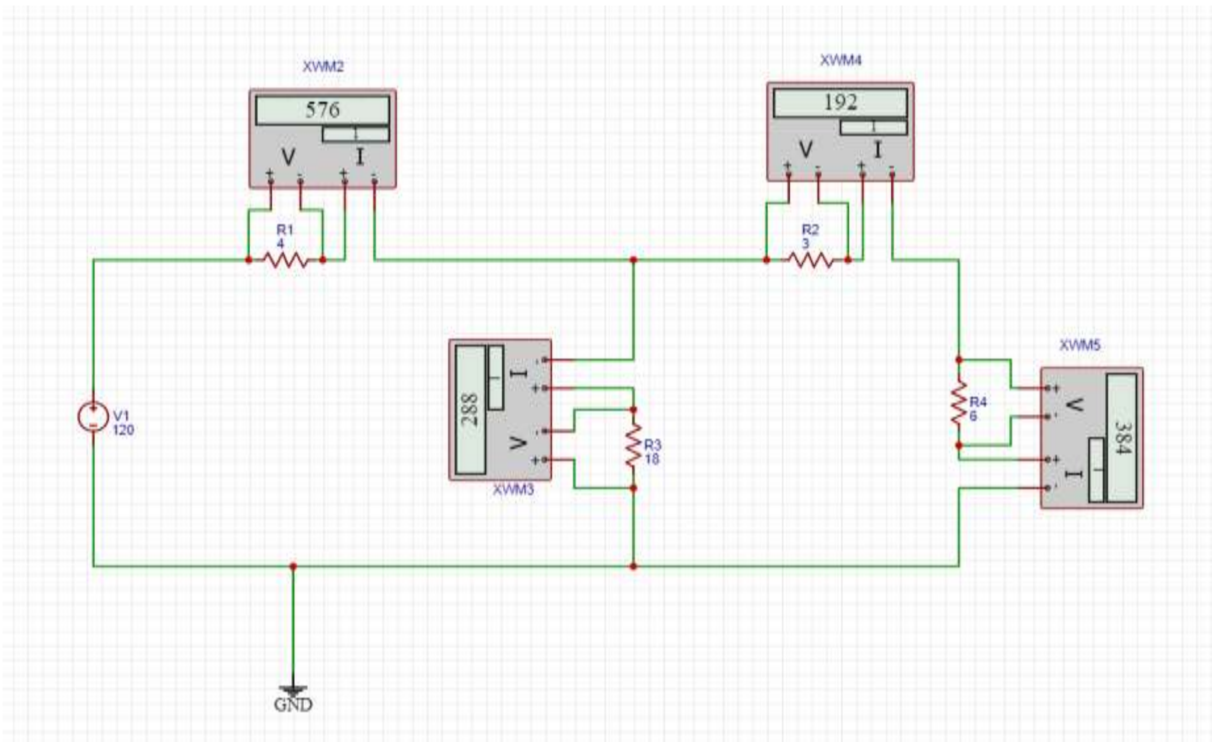
$V_y = \beta V_s = (0.8125) \cdot 8 = 6.5\,V$

EasyEDA simulations

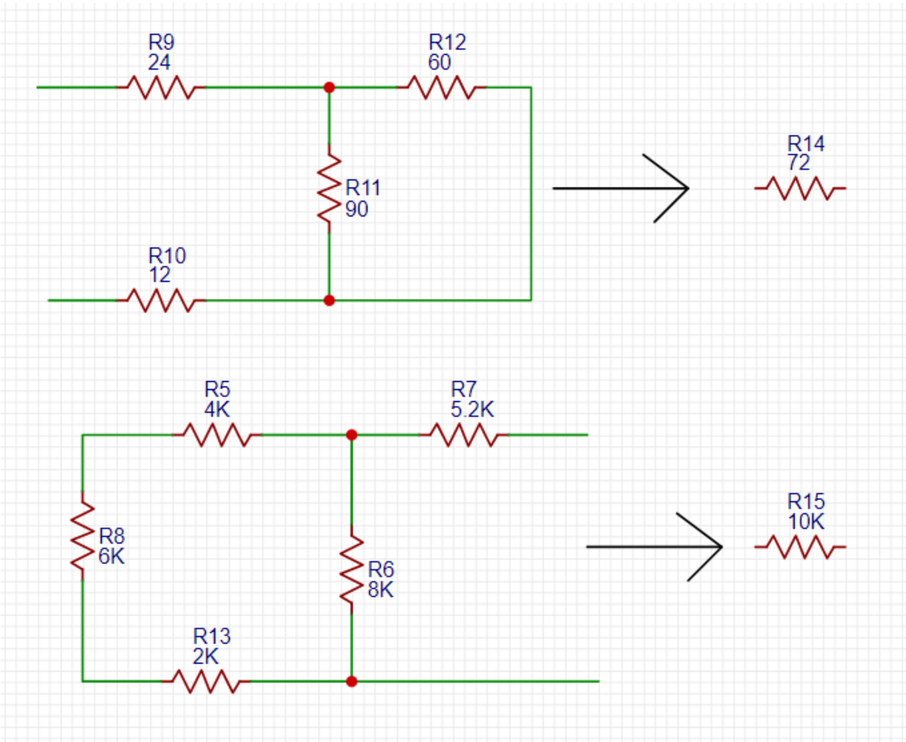
- **3.1**



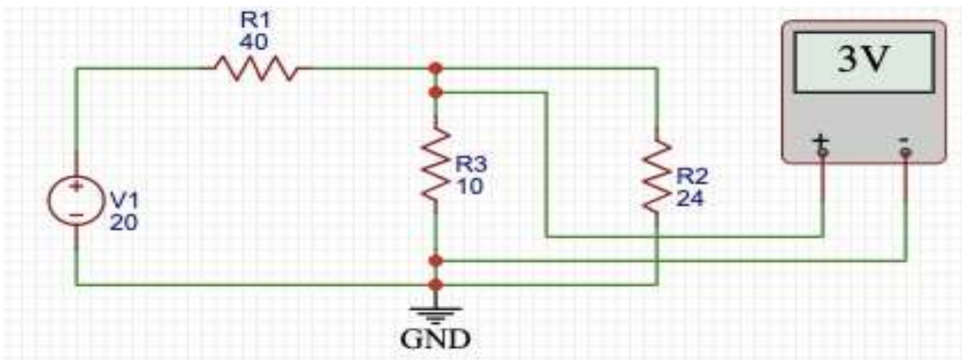
- **3.2**



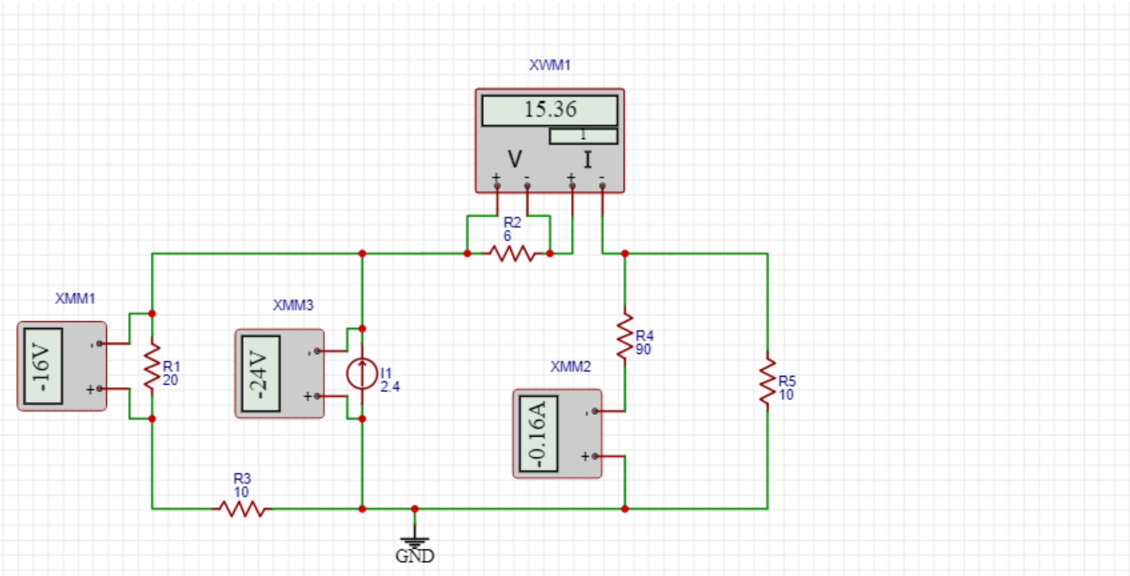
- ***3.8***


R9
24
R12
60
R11
90
R10
12
R14
72
R5
4K
R7
5.2K
R8
6K
R6
8K
R13
2K
R15
10K

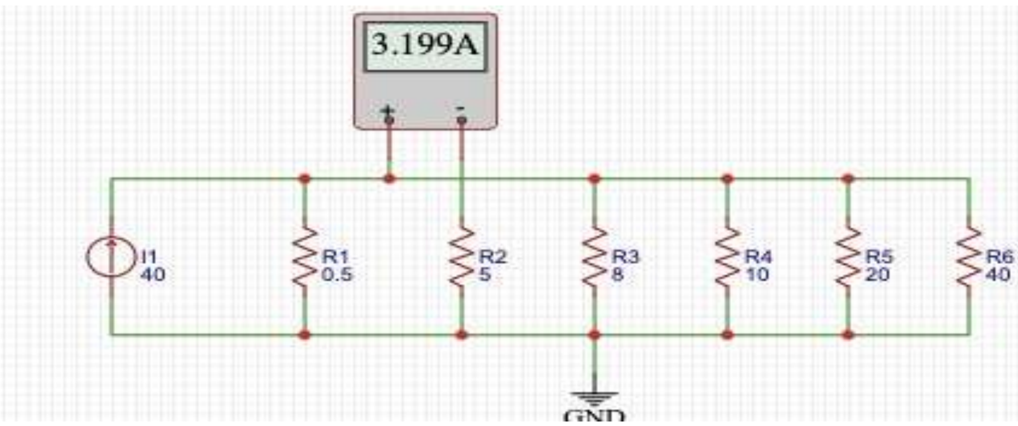
- ***3.13***


R1
40
3V
R3
10
R2
24
V1
20
GND

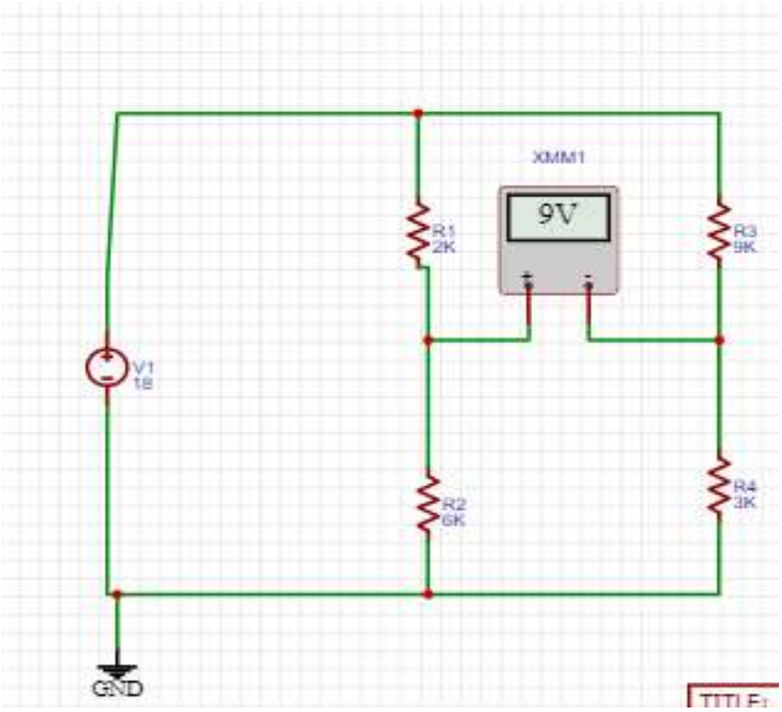
- ***3.17***


XWM1
15.36
V
I
+
-
+
-
R2
6
XMM1
-16V
R1
20
XMM3
-24V
I1
2.4
R4
90
XMM2
-0.16A
R5
10
R3
10
GND

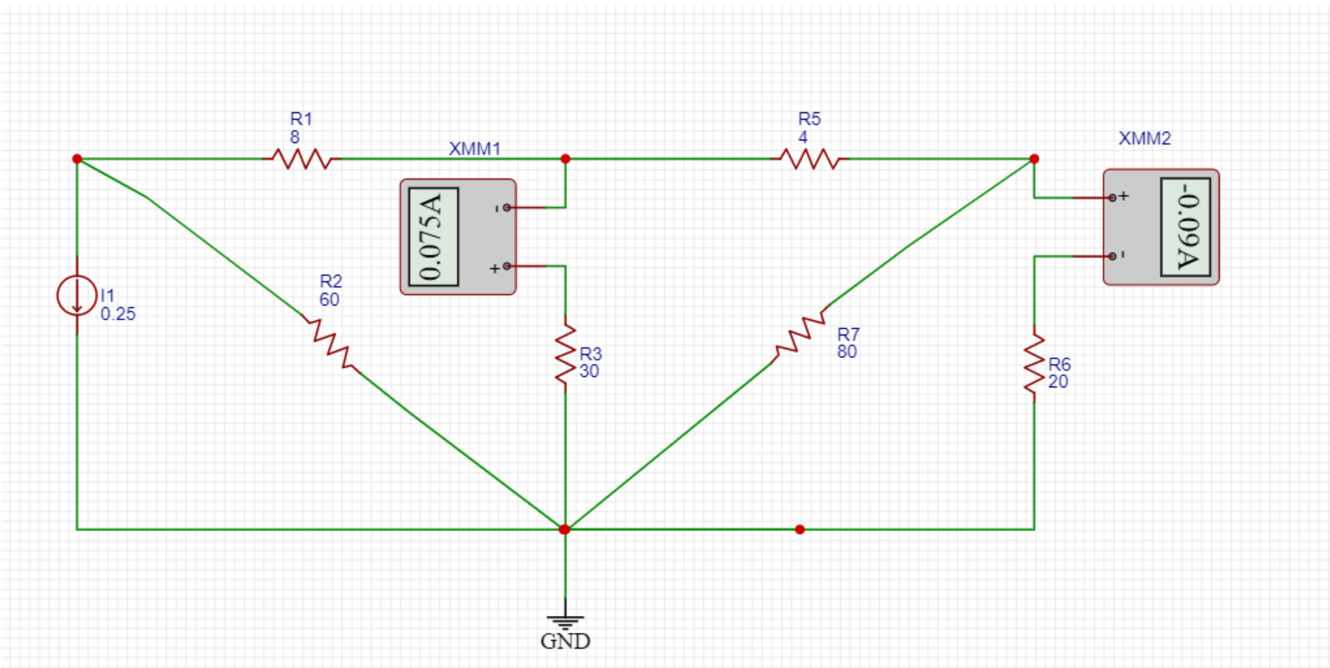
- ***3.22***


3.199A
+
-
I1
40
R1
0.5
R2
5
R3
8
R4
10
R5
20
R6
40

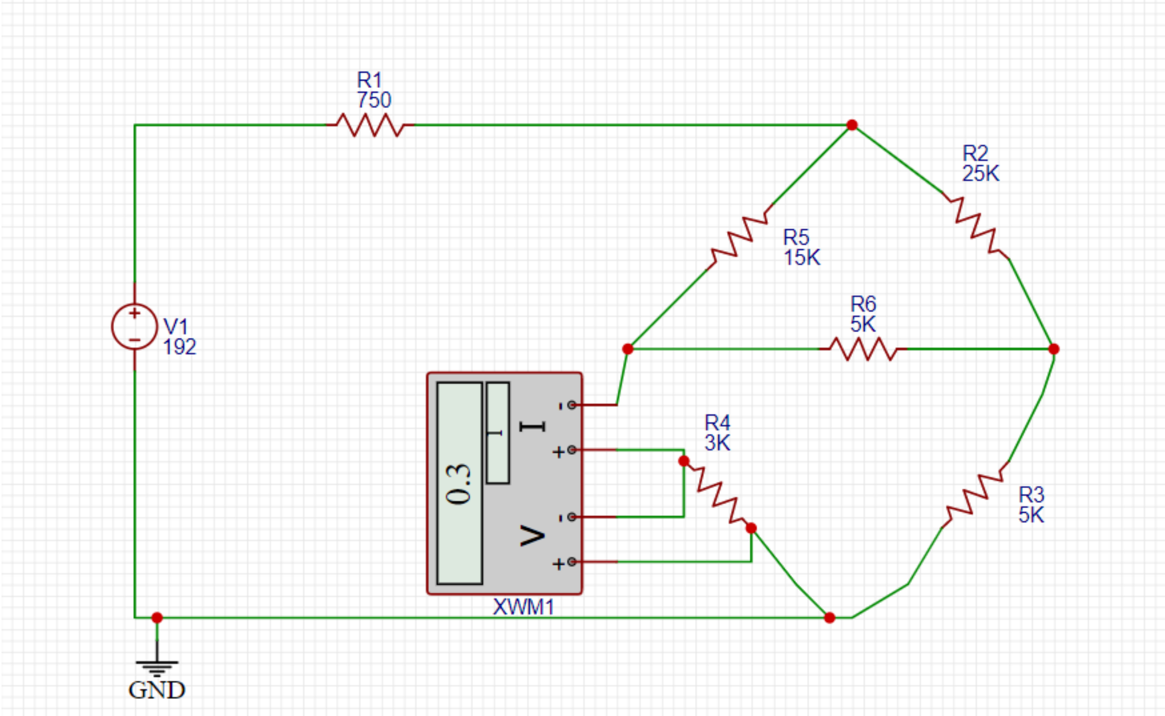
- **3.28**


XMM1
9V
R1
2K
R3
9K
V1
18
R2
6K
R4
3K
GND

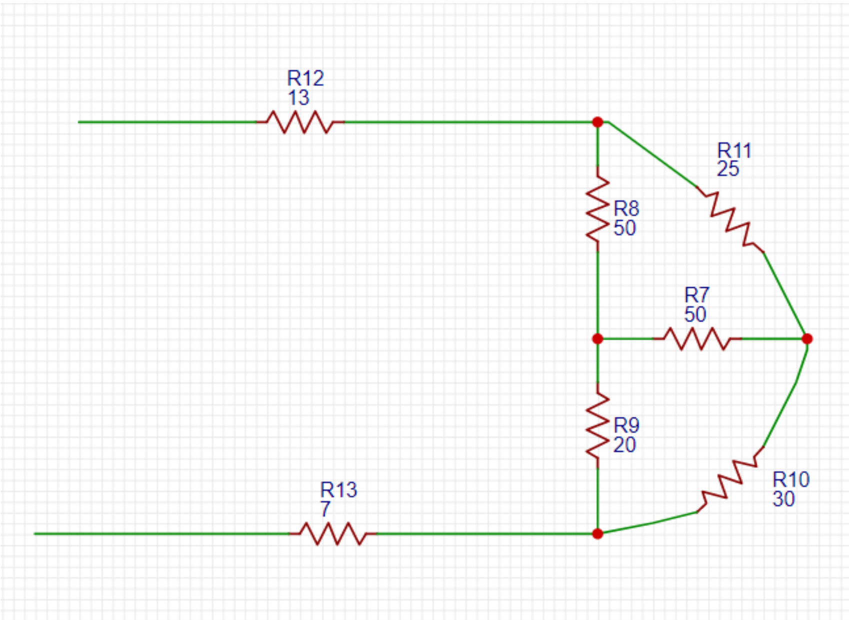
- **3.32**


R1
8
XMM1
R5
4
XMM2
0.075A
-0.09A
I1
0.25
R2
60
R3
30
R7
80
R6
20
GND

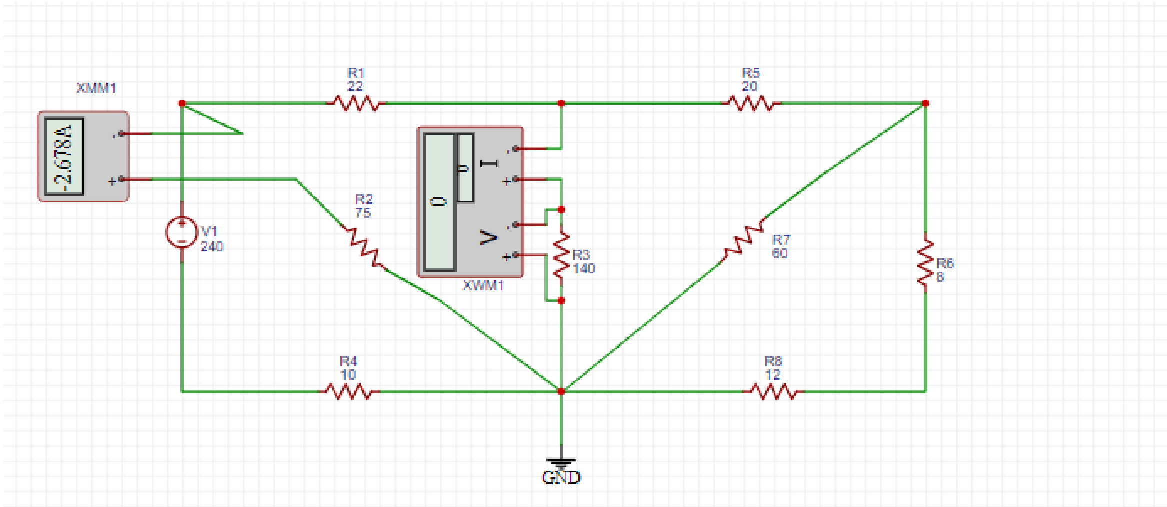
- ## 3.52


R1
750
R2
25K
R5
15K
R6
5K
V1
192
R4
3K
R3
5K
0.3
I
V
XWM1
GND

- ## 3.58


R12
13
R11
25
R8
50
R7
50
R9
20
R10
30
R13
7

- ***3.62***



XMM1
-2.678A
R1
22
R5
20
R2
75
V1
240
XWM1
R3
140
R7
60
R6
8
R4
10
R8
12
GND