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.

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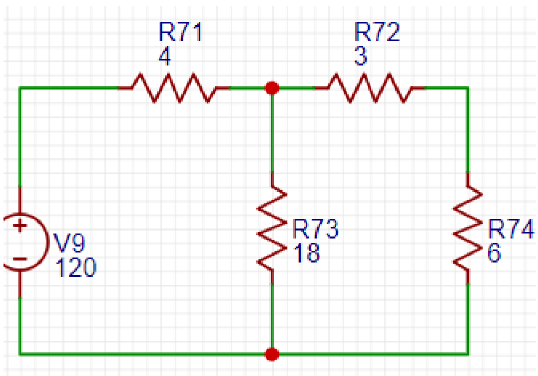
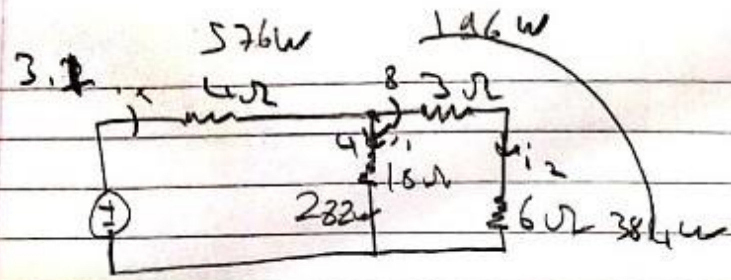
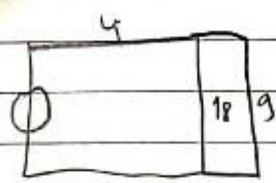
b) Show that the solution of the circuit in Fig. 3.9 satisfies Kirchhoff's voltage law around every closed loop.



3.1



$$\begin{array}{r} 16 \\ \times\ 18 \\ \hline 128 \\ 16 \\ \hline 288 \end{array}$$



$$\frac{9 \cdot 18}{27} = \boxed{6}$$

$$i_x = \frac{120}{10} = 12$$

$$\boxed{\text{So } i_1 = 4,\ i_2 = 8}$$

b $= 12 \times 12 = \boxed{144W}$

c $= 576 + 196 + 384 + 288 = 1440$

3.2

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

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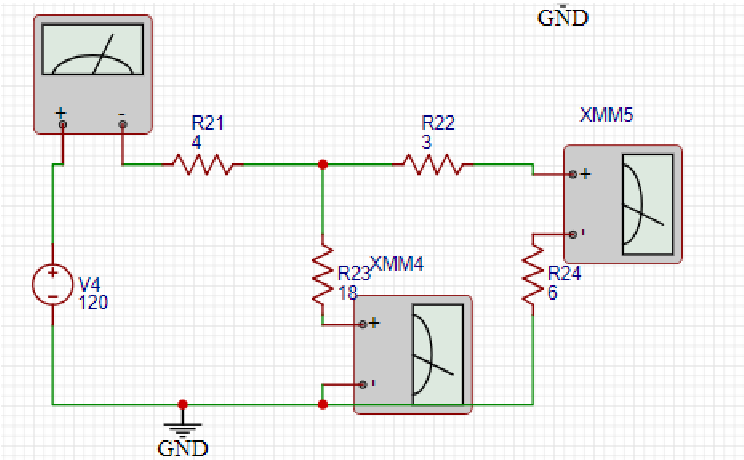
b) Find the power delivered by the 120 V source.

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



3.2

(a) $P_{4\Omega} = i^2 4 = 12^2 \cdot 4 = \boxed{576\text{ watt}}$ $\quad P_{16\Omega} = 288\text{ watt}$

$P_{3\Omega} = 192\text{ Watt}$ $\quad P_{6\Omega} = 384\text{ Watt}$

(b) $P_{120} = 120 i = 120 \times 12 = 1440\text{ watt}$

Correct

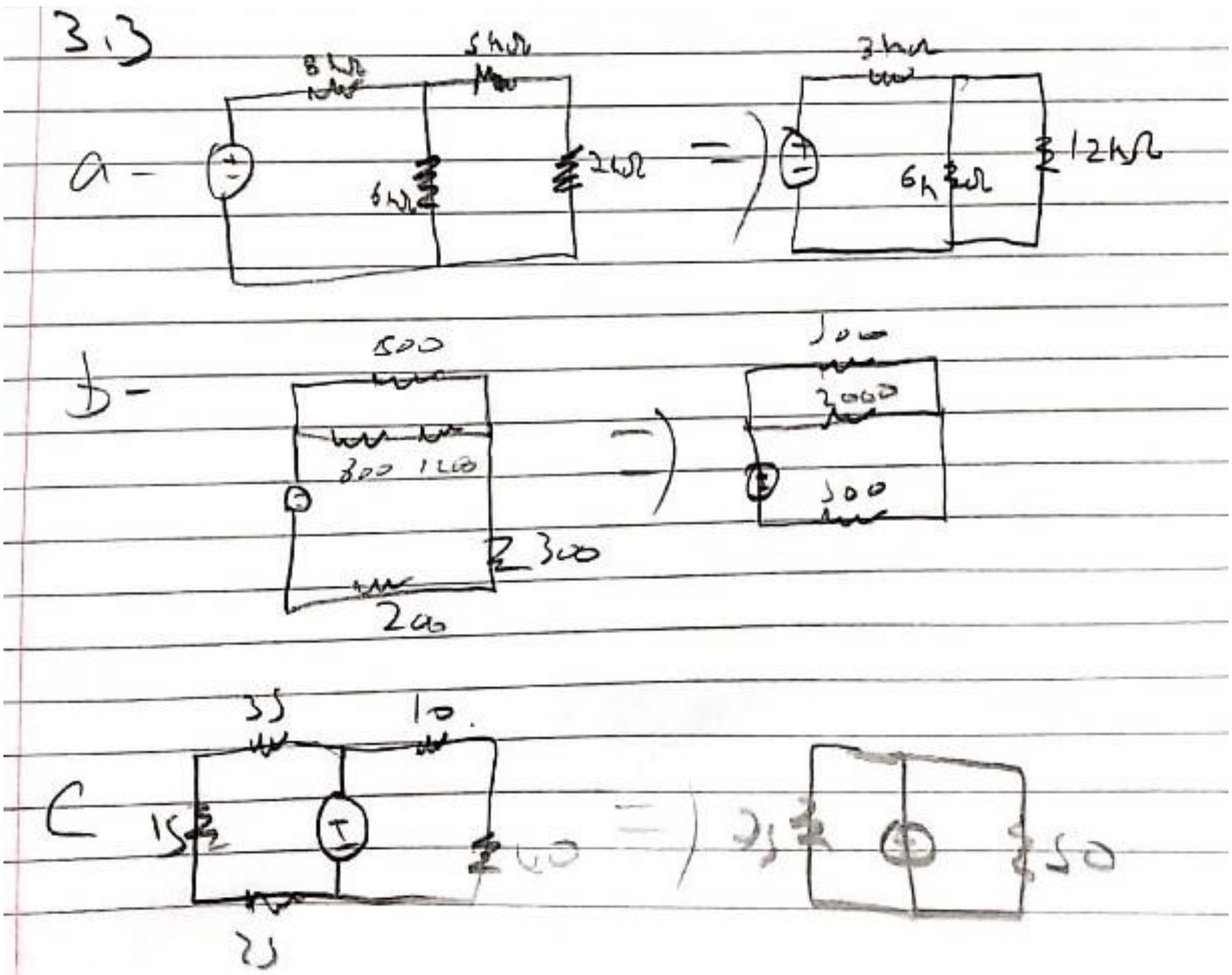
(c) $P_{diss} = 576 + 288 + 192 + 384 = 1440\text{ W}$

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.

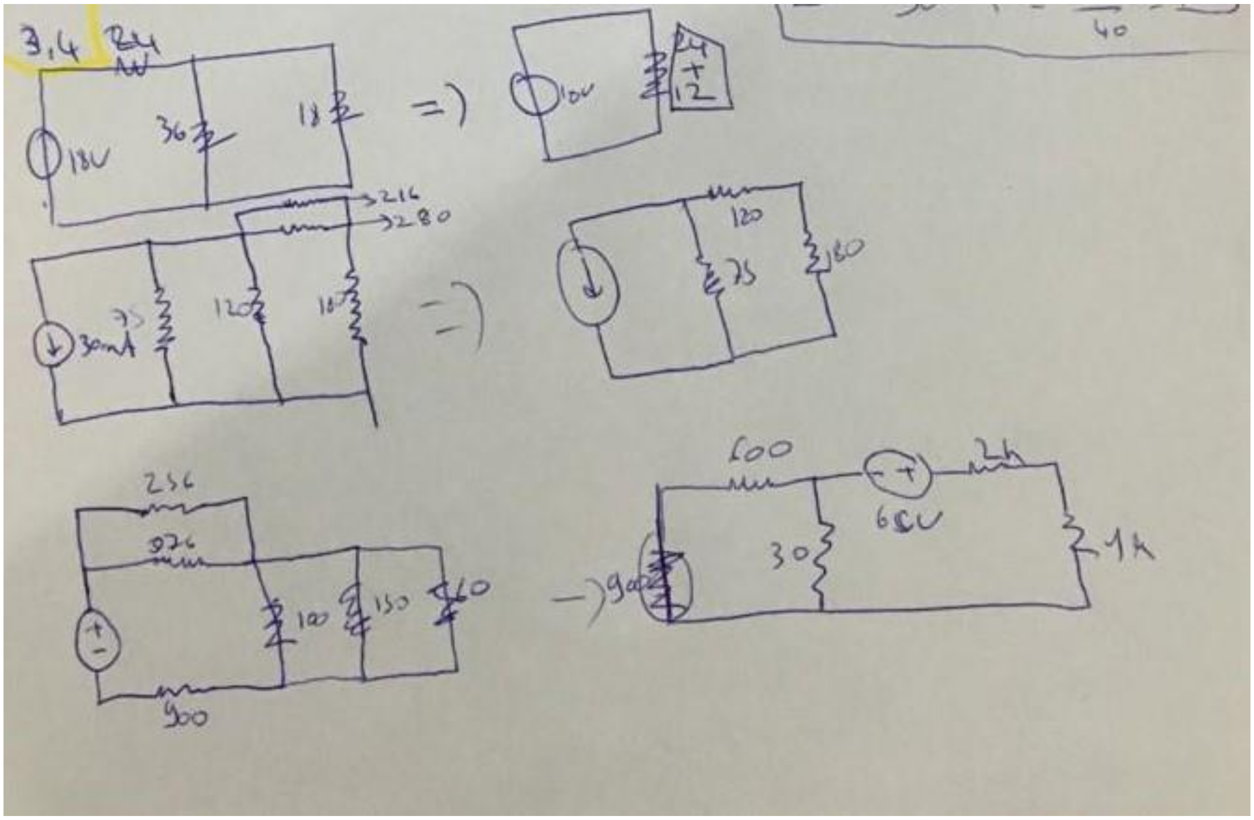


3.4

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.



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.

3,5

$R_{eq} = [(7000 + 5000) \| 6000] + 800 = 12{,}000 \| 6000 + 8000$

$= 4000 + 8000 = 12\ k\Omega$

$R_{eq} = [500 \| (800 + 1200)] + 300 + 200 = (500 \| 2000) + 300 + 200$

$= 400 + 300 + 200 = 900\,\Omega$

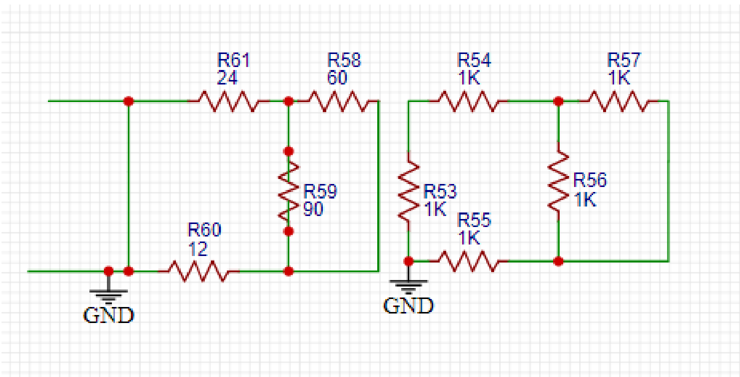
$R_{eq} = (35 + 15 + 25) \| (10 + 40) = 75 \| 50 = 30\,\Omega$

$R_{eq} = ([(70 + 80) \| 100] + 50 + 90) \| 300 = [(150 \| 100) + 50 + 90] \| 300$

$= (60 + 50 + 90) \| 300 = 200 \| 300 = 120\,\Omega$

3.8

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



3.8

(a) $R_{ab} = 24 + 90 \| 60 + 12 = 24 + 36 + 12 = 72\,\Omega$

(b) $R_{ab} = 12k \| 6k + 5.2k = 10k\,\Omega$

(c) $R_{ab} = 1200 \| 720 \| 800 \Rightarrow 288\,\Omega$

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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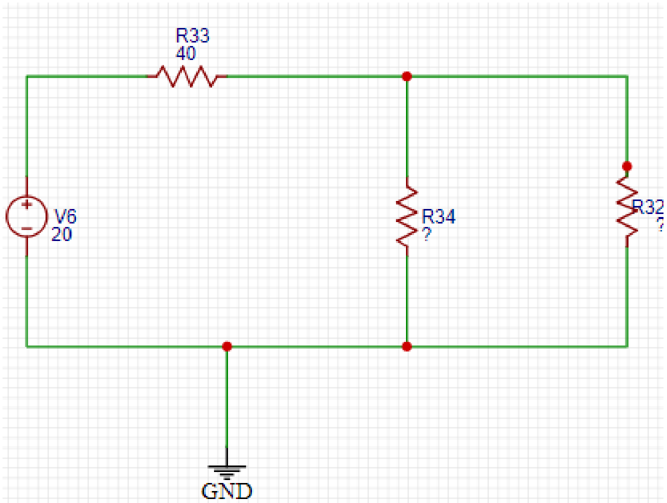

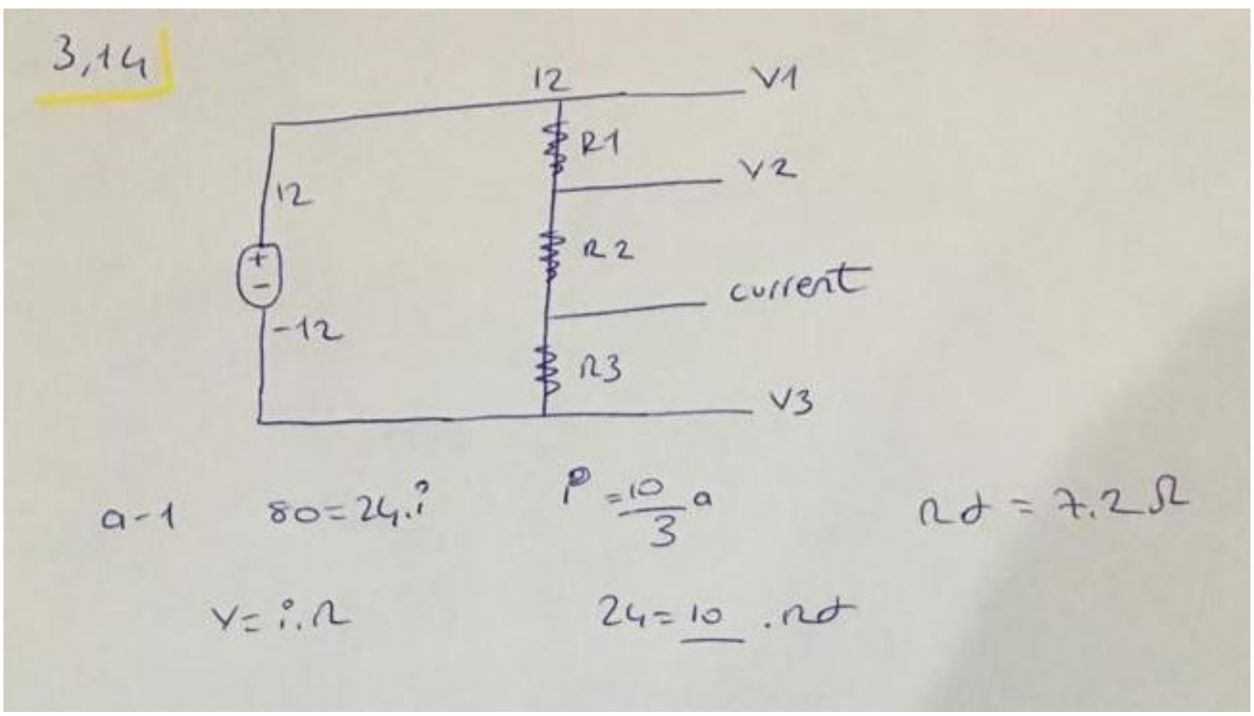

3.17

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

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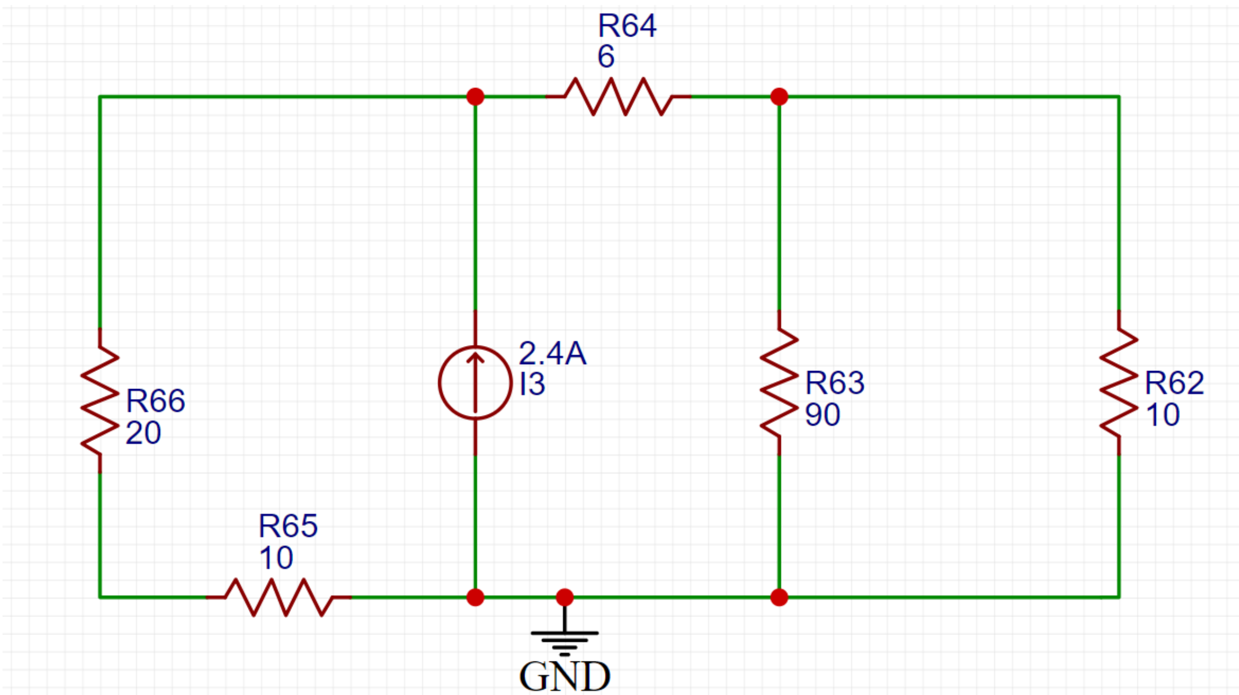
a) i_o and v_o.

b) the power dissipated in the 6 Ω resistor.

c) the power developed by the current source.

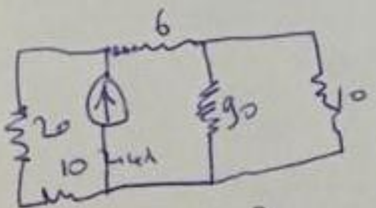


3.17

$R_{eq} = 30 \| (12 + 90\|10) = 30\|15 = 10\Omega$

$V_{2.4} = 10 \cdot 2{,}4 = \boxed{24}$ / $V_0 = V_{20\Omega} = \frac{20}{30} 24 = \boxed{16V}$

$V_{90\Omega} = \frac{90\|10}{6 + 90\|10} (24) = \frac{9}{15} 24 = \boxed{14.4V}$



a- $\boxed{i_0 = \frac{14.4}{90} = 0.16A}$

(b) - $\frac{(24 - 14.4)^2}{6} = \boxed{15.36 \text{ Watt}}$

(C) $(-2.4) \cdot 24 = \boxed{-57.6 \text{ Watt}}$

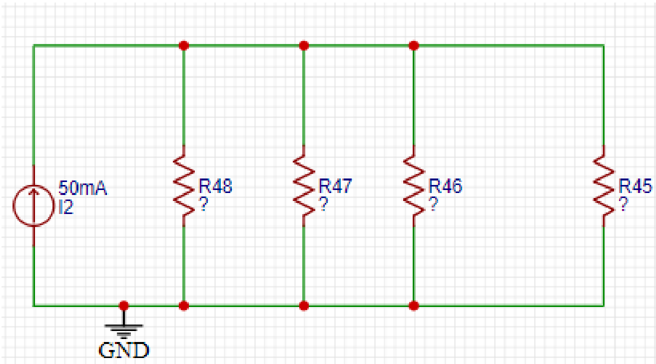
3.18

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 $i_4 = 4i_1$.



3,18

$0,05 = i_1 + i_2 + i_3 + i_4 = 0.6i_2 + i_2 + 2i_2 + 4i_4 = 0.6i_2 + i_2 + 2i_2$

$+ 4(0.6i_2) = 6i_2$

$i_2 = 0,05/6 = 0,00833 = 8.33$ mA

$i_1 = 0.6i_2 = 0.6(0.00833) = 0,005 = 5$ mA

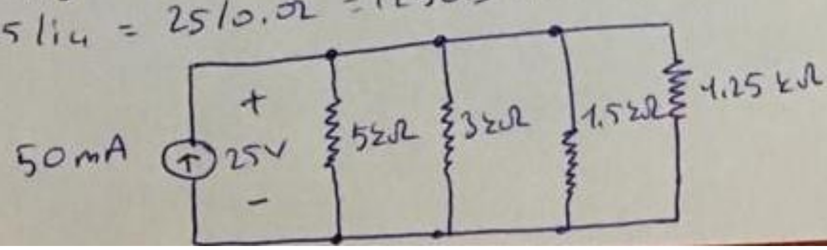
$i_3 = 2i_2 = 2(0.00833) = 0,01667 = 16.67$ mA

$i_4 = 4i_1 = 4(0.005) = 0,02 = 20$ mA

$R2 = 25/i_2 = 25/0.00833 = 3000 = 3\,\Omega$

$R3 = 25/i_3 = 25/0,01667 = 1500 = 1.5\,k\Omega$

$R4 = 25/i_4 = 25/0.02 = 1250 = 1.25\,k\Omega$

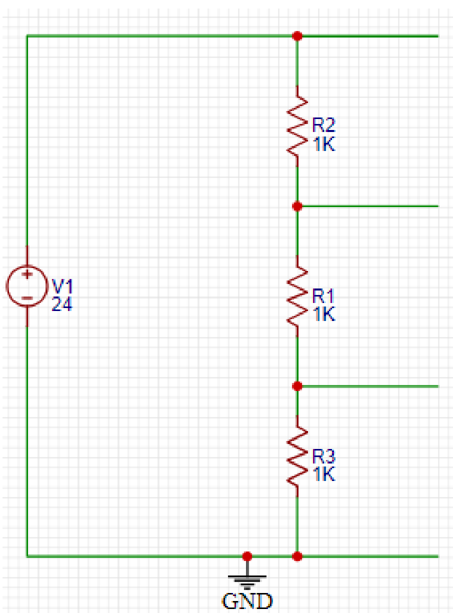


3.19

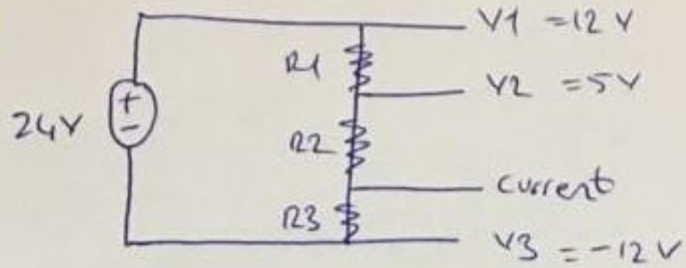
There is often a need to produce more than one voltage using a voltage divider. For example, the memory components of many personal computers require voltages of −12 V, 5 V, and +12 V, all with respect to a common reference terminal. Select the values of R_1, R_2, and R_3 in the circuit in Fig. P3.19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



3,19



$W=80$

$W = V.i$

$80=24.i$

$i = \frac{10}{3}$ A

$V= i.R$

$\frac{V}{I} = R$

$R1 = \frac{12-5}{\frac{10}{3}} = 2.1\,\Omega$

$R2 = \frac{5}{\frac{10}{3}} = 1,5\,\Omega$

$R3 = \frac{-(-12)}{\frac{10}{3}} = 0,6\,\Omega$

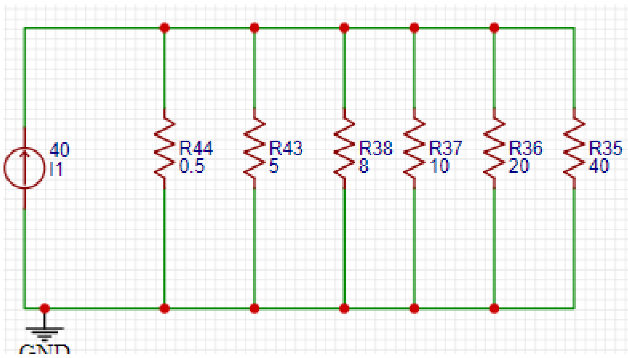
2,1 Ω
1,5 Ω
3,4 Ω

3.22

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,

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

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



3,22

$$i_g = V_o G_1 + V_o G_2 + \dots + V_o G_N = V_o(G_1 + G_2 + \dots G_N)$$

$$V_o = \frac{i_g}{(G_1 + G_2 + \dots + G_N)}$$

$$i_k = V_o G_k;$$

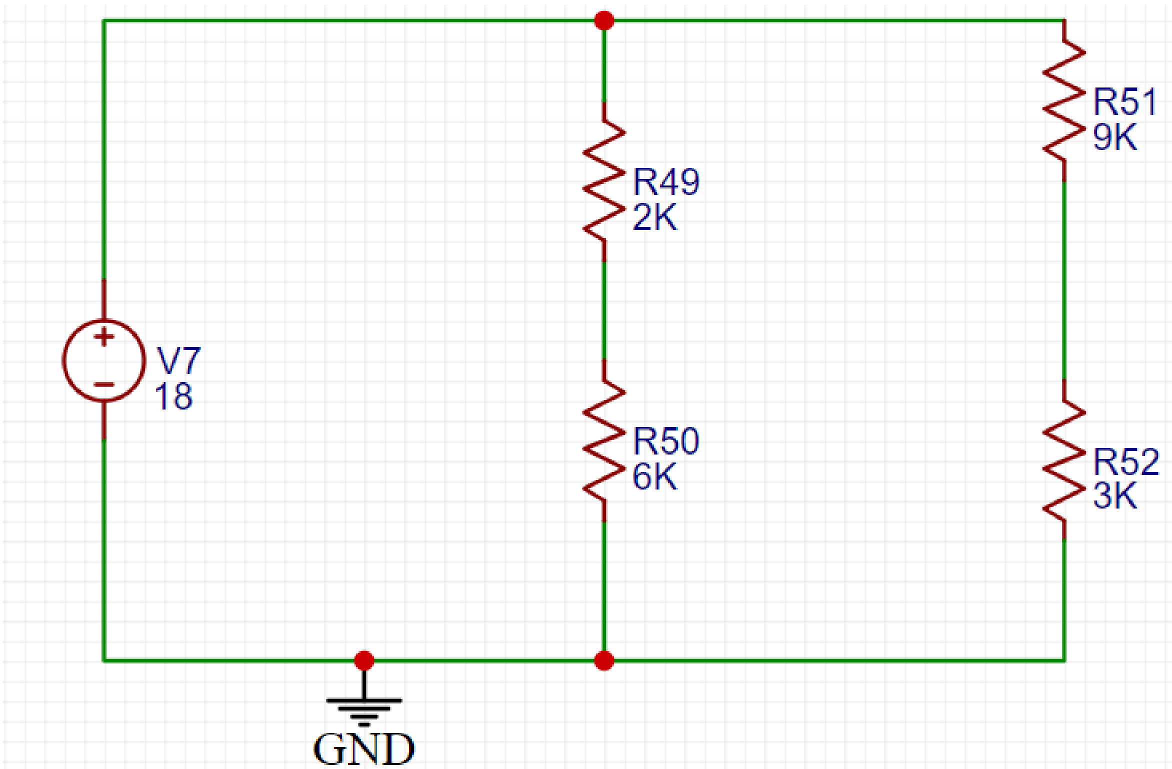
$$i_k = \frac{i_g G_k}{[G_1 + G_2 + \dots + G_N]}$$

$$i_5 = \frac{40\,(0{,}2)}{2 + 0{,}2 + 0{,}125 + 0{,}1 + 0{,}05 + 0{,}025} = 3.2\,A$$

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.



3.28

(a) $V_{6k} = \frac{6}{8} \cdot 18 = \boxed{13.5V}$

$V_{3k} = \frac{3}{12} \cdot 18 = \boxed{4.5V}$

$\boxed{V_x = V_{6k} - V_{3k} = 9V}$

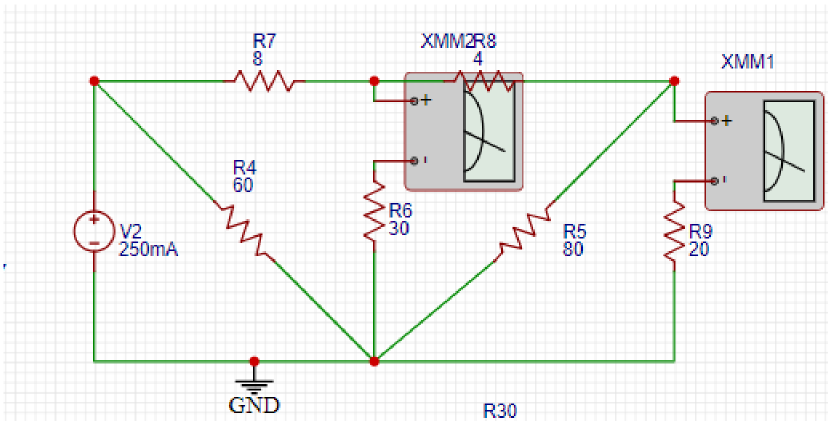
(b) $V_{6k} = \frac{6}{8} V_s =$ [redacted] $\cdot \frac{3}{4} V_s$

$V_{3k} = \frac{1}{4} V_s$

$\boxed{V_x = 0.5 V_s}$

3.32

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



3.32

$$R_{eq} = \underbrace{(20\|80 + 4)\|30}_{12} + 8 = 20$$

$$i_8 = \frac{60\|R_{eq}}{R_{eq}}(0.25) = \boxed{187.5\,mA}$$

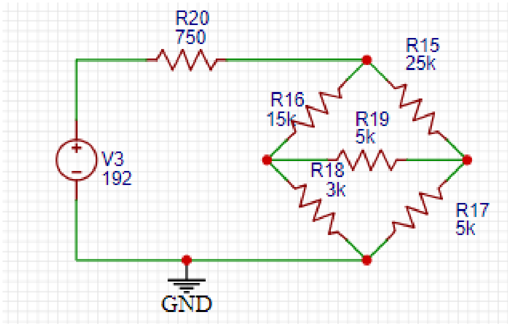
$$i_1 = \frac{30\|(4+80\|20)}{30}\, i_8 = 0{,}075 = 0{,}75\,mA$$

$$i_{4\Omega} = \frac{30\|(4+80\|20)}{4+80\|20}\, i_8 = 0{,}1125 = 112.5\,mA$$

$$i_2 = \frac{80\|20}{20}(i_{4\Omega}) = 0{,}09 = 90\,mA$$

3.52

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



3,52 $R_{eq} = 750 + (15{,}000 + 3000) \parallel (25{,}000 + 5000) = 750 + 11{,}250$

$= 12\ k\Omega$

Source current $= 192 / 12{,}000 = 16\ mA$

The current will move on the 15 kΩ and 3 kΩ

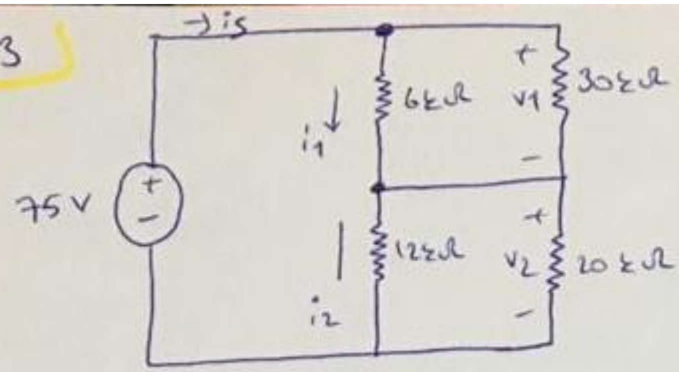
$$i_{3k} = \frac{11{,}250}{18{,}000}(0{,}016) = 10\ mA$$

$$P_{3k} = 3000\,(0{,}01)^2 = 0{,}3\ W$$

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.

3,53



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

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

$i_s = \dfrac{75}{12{,}500} = 6\ mA$

$V1 = 0{,}006(5000) = 30\ V$

$V2 = 0{,}006(7500) = 45\ V$

$i_1 = \dfrac{30}{6000} = 5\ mA$

$i_d = i_1 - i_2 = 1{,}25\ mA$

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.

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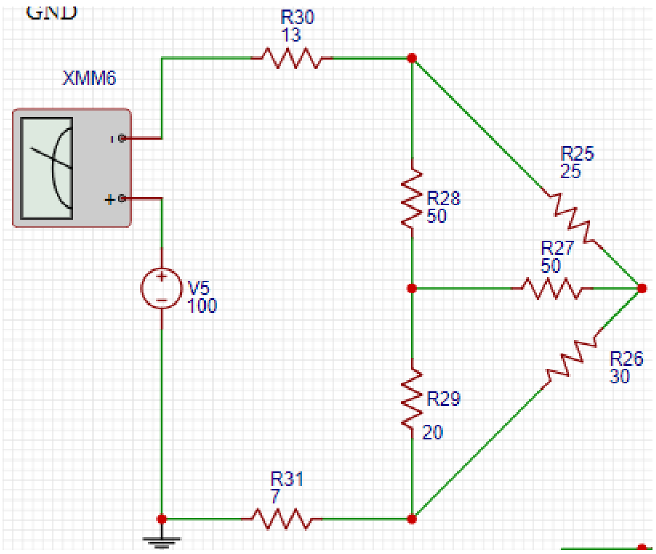
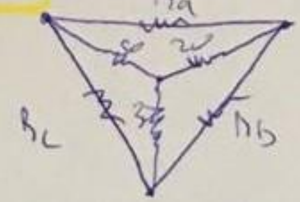
b) Repeat (a) using a Δ-to-Y transformation involving resistors R_3, R_4, and R_5.

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



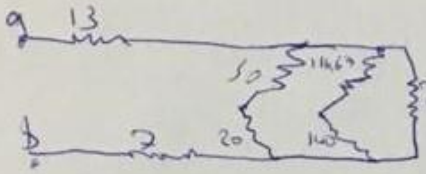
3.58

(a)



$R_A = \frac{25\cdot30 + 25\cdot50 + 30\cdot50}{30} \quad \frac{3500}{30} = 116.67\,\Omega$

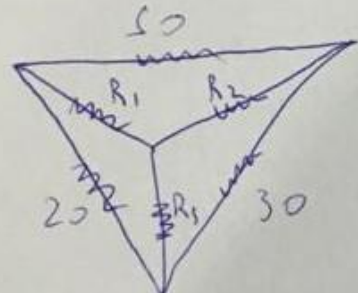
$\boxed{R_b = 70\,\Omega}$ $\boxed{R_c = 140\,\Omega}$



$70 \,||\, (50 \,||\, 116.67) + 20 \,||\, 140 = \boxed{30}$

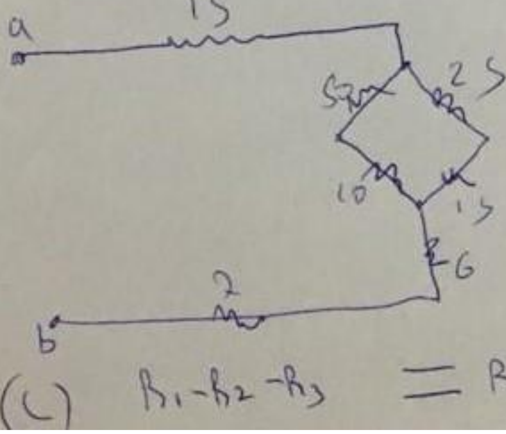
$R_{ab} = 13 + 30 + 7 = \boxed{50}$

(b)



$R_1 = \frac{50\cdot20}{50+20+30} = 10 \quad R_2 = \frac{50\cdot30}{50+20+30} = 15$

$R_3 = \frac{20\cdot30}{50+20+30} = 6\,\Omega$



$(50+10) \,||\, (25+15) + 6 = 30$

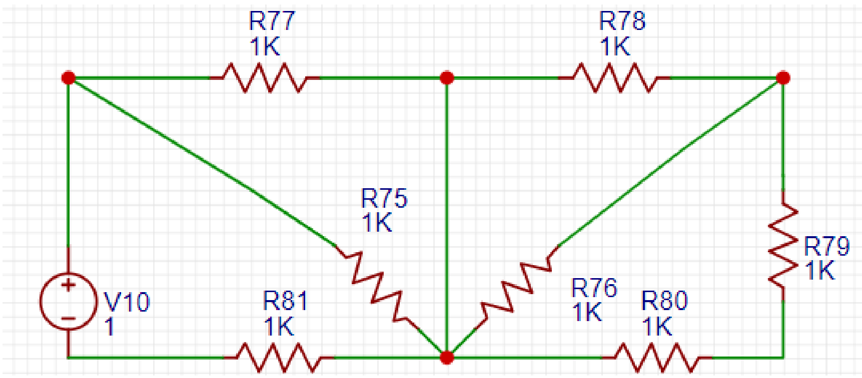
$\boxed{R_{ab} = 13 + 30 + 7 = 50}$

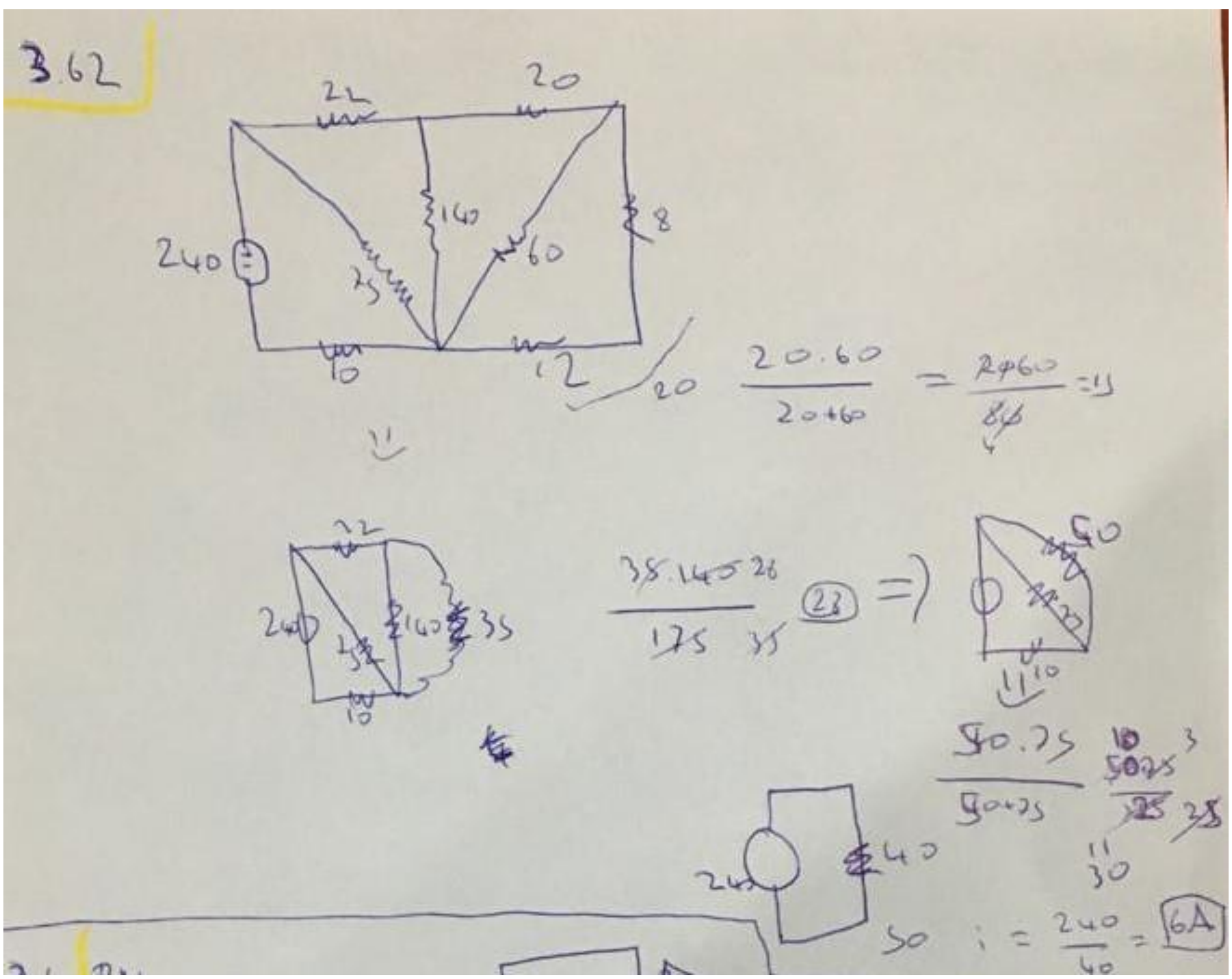
(c) $R_1 - R_2 - R_3 \;=\; R_1 - R_3 - R_4$

3.62

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

For the circuit shown in Fig. P3.63, find (a) i_1, (b) v, (c) i_2, and (d) the power supplied by the voltage source.



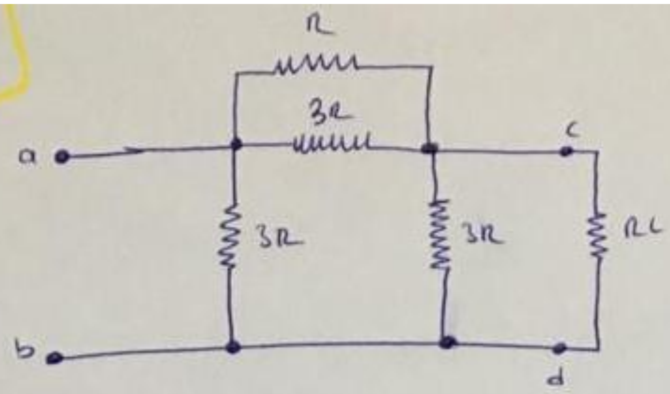


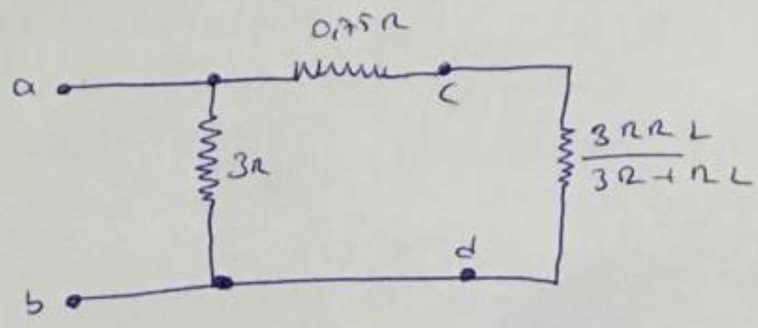
3.67

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 $R = R_L$.

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

3,67





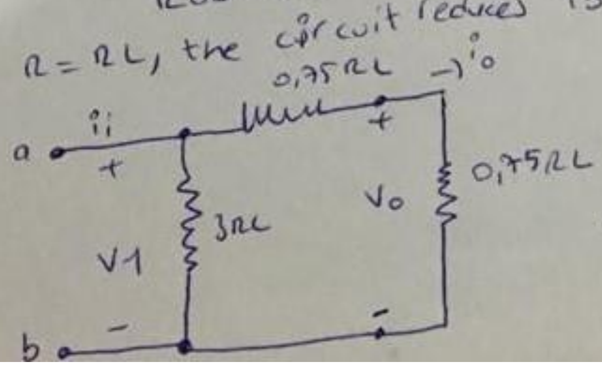
$$0{,}75R + \frac{3R\,R_L}{3R + R_L} = \frac{2.25R^2 + 3.75\,R R_L}{3R + R_L}$$

$$R_{ab} = \frac{3R\left(\frac{2.25R^2 + 3.75\,R R_L}{3R + R_L}\right)}{3R\left(\frac{2.25R^2 + 3.75\,R R_L}{3R + R_L}\right)} = \frac{3R(3R + 5R_L)}{15R + 9R_L}$$

If $R = R_L$, we have $R_{ob} = \frac{3R_L(8R_L)}{24R_L} = R_L$

$R_{ob} = R_L$

When $R = R_L$, the circuit reduces to



$$i_o = \frac{i_i(3R_L)}{4{,}5R_L} = \frac{1}{1.5} i_i$$

$$= \frac{1}{1.5}\,\frac{V1}{1{,}R_L},$$

$$\to \frac{V_o}{V_i} = 0{,}5$$

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 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.

3,73

$V_x = \alpha . V_5$

$V_y = \beta . V_5$

$\frac{1}{5} = \alpha \qquad \alpha = 0{,}2$

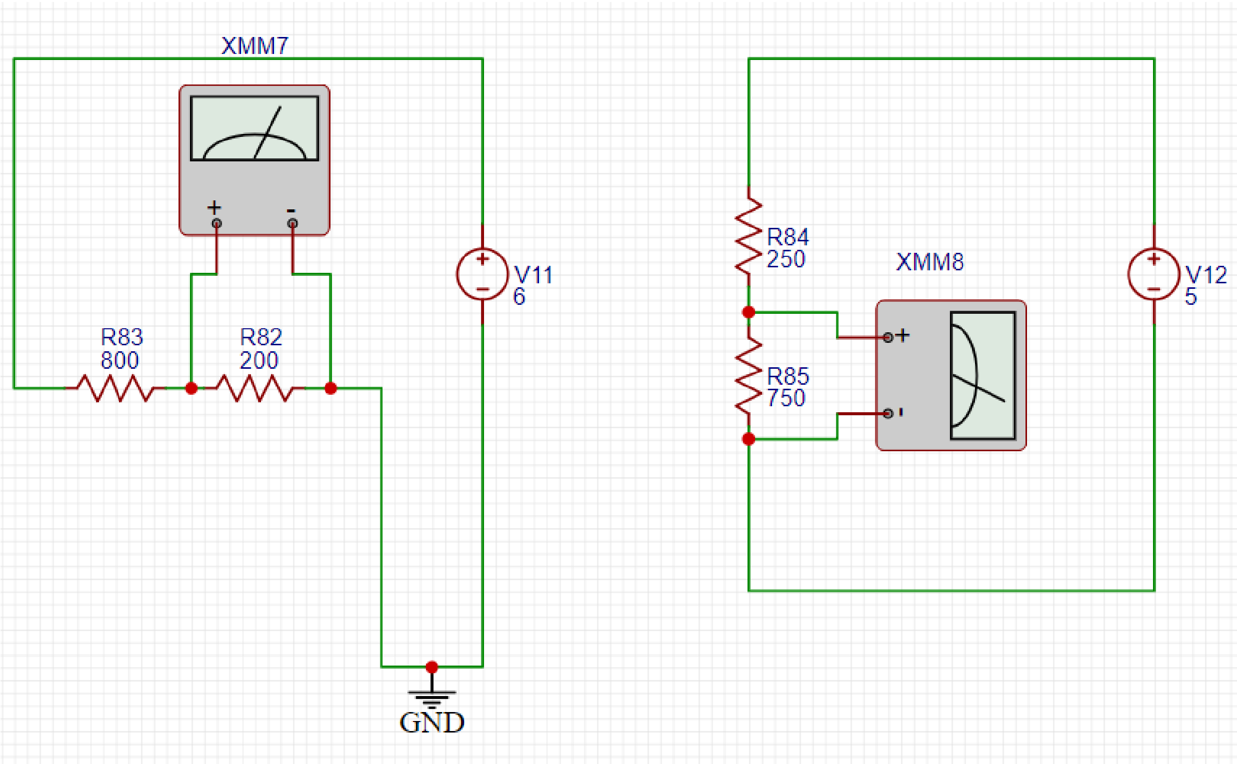
$\beta = \frac{V_4}{V_5} = \frac{0{,}75}{5} = 0{,}25$

$x = (1-\alpha)\, p.x = (1 - 0.2) . 480 = 384$

$y = (1-\beta) . p.a = (1-0{,}75) . 800 = 200$

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.



3,74

$x = (1-a)\,px$

$640\,(1-a) = 480$

$1-a = \frac{2}{4} \qquad a = \frac{1}{4}$

640,1024

480,142

$Vx = V5a \qquad Vx_2 = 8 \cdot \frac{1}{4} = 2V$

$y = (1-\beta)\,Py$

$Vy = 8 \cdot 0{,}8125$

$Vy = 6{,}5\,V$

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

$260 = (1-\beta) \cdot 2^{10}$

$\frac{3}{16} = 1-\beta$

$\beta = \frac{13}{16} = 0{,}8125$