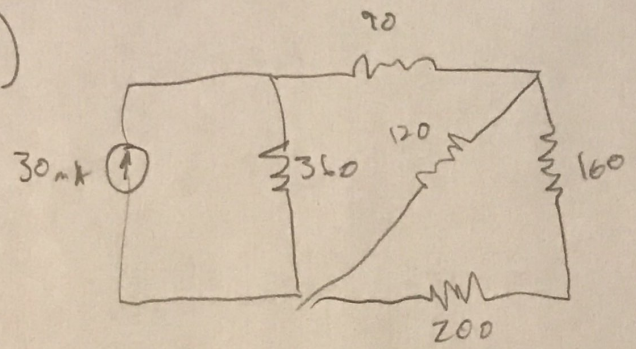
HW 3

Daren Liu

1) Voltage dividers require two or more resistors in series, while a current divider requires two or more resistors in parallel.

2) a)

a.



$200 + 160 = 360$

$\frac{1}{R_{eq}} = \frac{1}{360} + \frac{1}{120} = 90\ \Omega$

$90 + 90 = 180$

$R_{eq} = \frac{1}{180} + \frac{1}{360} = \underline{120\ \Omega}$

b. $R_1 = 150 + 600 = 750$

$R_2 = \left(\frac{1}{500} + \frac{1}{750}\right)^{-1} = 300$

$R_3 = 300 + 300 = 600\ \Omega$

$R_4 = 750 + 250 = 1000\ \Omega$

$R_5 = \left(\frac{1}{1000} + \frac{1}{1000}\right)^{-1} = 500\ \Omega$

$R_6 = 500 + 100 = 600$

$R_{eq} = \left(\frac{1}{600} + \frac{1}{600}\right)^{-1} = \boxed{300\ \Omega}$

c. $R_1 = 6 + 14 = 20$

$R_2 = \frac{1}{\frac{1}{12} + \frac{1}{4} + \frac{1}{20} + \frac{1}{15} + \frac{1}{20}} = 2\ \Omega$

$R_3 = 16 + 2 = 18\ \Omega$

$R_4 = \left(\frac{1}{18} + \frac{1}{14}\right)^{-1} = 9\ \Omega$

$R_{eq} = 8 + 9 + 10 = \boxed{27\ \Omega}$

d. $R_1 = \left(\frac{1}{30} + \frac{1}{15}\right)^{-1} = 10\ \Omega$

$R_2 = 20 + 10 = 30\ \Omega$

$R_3 = \left(\frac{1}{60} + \frac{1}{30}\right)^{-1} = 20\ \Omega$

$R_4 = 10 + 20 = 30\ \Omega$

$R_5 = \left(\frac{1}{60} + \frac{1}{80} + \frac{1}{30}\right)^{-1} = 16\ \Omega$

$R_{eq} = 50\ \Omega$

b) $V_a = (30m)(120) = 3.6\,V$

$P_a = (30)(3.6) = 108\,mV$

$V_b = (50)(300) = 15\,V$

$P_b = (50)(15) = 750\,mW$

$I_c = \frac{144}{27} = 5.33\,A$

$P_c = (5.33)(144) = 767.995\,W$

$I_d = \frac{90}{50} = 1.6\,mA$

$P_d = (80\Omega)(1.6) = 128\,mW$

3) a) $\left(\frac{1}{30+120} + \frac{1}{75}\right)^{-1} = 50\,k\Omega$

$V_1 = \frac{50 \cdot 240V}{75} = 160\,V$

$V_o = \frac{120}{150} \cdot 160 = 128\,V$

b) $i = \frac{V}{R}$

$\frac{240}{(100)}A = 2.4\,mA$

$V_o = \frac{120}{150} \cdot 180 = 144\,V$

c) $V_o = 144$ with dependent voltage

$V_o = 128V$ without

dependent voltage source = higher voltage output

4) a) $V_6 = kV = \frac{R_2}{R_1+R_2} V_S$

$V_o = \alpha V_S = \frac{R_L}{R_1+R_L} V_S$

$k = \frac{R_2}{R_1+R_2}$ $\quad R_1 = \frac{1-k}{k} R_2$

$\alpha = \frac{R_L}{R_1+R_2}$ $\quad R_1 = \frac{(1-\alpha)}{\alpha} R_L$

$R_2 = \frac{k-\alpha}{\alpha(1-k)} R_o$

$R_1 = \frac{k-\alpha}{\alpha k} R_o$

b) $R_1 = \left(\frac{0.05}{0.64}\right) R_o = \left(\frac{0.05}{0.64}\right) \cdot 34 \cdot 10^3 = 2.5 k\Omega$

$R_2 = \left(\frac{0.05}{0.12}\right) \cdot 34 \cdot 10^3 = 14.167 k\Omega$

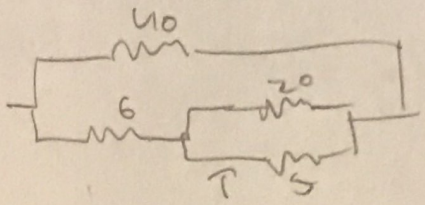
c) $P_{max_1} = \frac{[60 \cdot 0.85]^2}{14167} = 183.6 mW$

$P_{max_2} = \frac{[60 - 0.8 \cdot 60]^2}{2500} = 57.60 mW$

d) $P_{R_1} = \frac{60^2}{2000} = 1.44\ W$

$P_{R_2} = \frac{0^2}{14167} = 0$

5)



$4\ \Omega$

$R_{eq} = \left(\frac{1}{40} + \frac{1}{10}\right)^{-1} = 8\ \Omega$

$-125 + (i_g 2) + (i_g 8) = 0$

$10 i_g = 125$

$i_g = 12.5\ A$

$i_1 = \frac{40}{50} \cdot 12.5 = 10\ A$

$i_0 = \frac{5}{25} \cdot 10 = 2A$

6) a) $R_{Volt} = 5000\ \Omega$

$R_{eq} = \left(\frac{1}{15} + \frac{1}{45} + \frac{1}{5000}\right)^{-1} = 11.22$

$V_{meas} = 11.22 \cdot 50\ mA = 561.23\ mV$

b) $R_{eq} = \left(\frac{1}{15} + \frac{1}{45}\right)^{-1} = 11.25\,\Omega$

$V_{true} = 11.25\,\Omega \cdot 50mA = 562.5\,mV$

$\%\ error = \left(\frac{561.23}{562.5} - 1\right) \cdot 100 = -0.2258\%$

c) $R_a = \frac{(22\times20)+(20\times140)+(140\times22)}{22} = 287.3\,\Omega$

$R_b = \frac{(22\times20)+(20\times140)+(140\times22)}{20} = 316\,\Omega$

$R_c = \frac{(22\times20)+(20\times140)+(140\times22)}{140} = 45.1\,\Omega$

$R_{eq_1} = \left(\frac{1}{287.3} + \frac{1}{60} + \frac{1}{28}\right)^{-1} = 14.25\,\Omega$

$\left(\frac{1}{316} + \frac{1}{75}\right)^{-1} = 60.6$

$\frac{R_L}{45.1+14.25} + \frac{1}{60.6} = 30\,\Omega$

$i_S = \frac{240}{40} = 6\,A$

$-240 + (1.75) + 10 i_S = 0$

$i_0 = 2.4\,A$

$i_S - i_0 - i_1 = 6 - 2.4 - i_1 = 0$

$i_1 = 3.6\,A$

$(i_1 \times 22) + (140 \times i_2) - (i_0 \times 75) = 0$

$140 i_2 = 100.8$

$i_2 = 0.72\ A$

$P_{140\Omega} = 72.5\ W$

8) a) $R_1 = 80 \quad R_2 = 20 \quad R_3 = 40$

$$R_a = \frac{(80)(20) + (20)(40) + (40)(80)}{80} = 70$$

$$R_b = \frac{(80)(20) + (20)(40) + (40)(80)}{20} = 280$$

$$R_c = \frac{(80)(20) + (20)(40) + (40)(80)}{40} = 140$$

$$R_{eq1} = \left(\frac{1}{56} + \frac{1}{140}\right)^{-1} = 40$$

$$R_{eq2} = \left(\frac{1}{210} + \frac{1}{20}\right)^{-1} = 52.5$$

$$R_{eq3} = 40 + 52.5 = 92.5$$

$$R_{eq4} = \left(\frac{1}{920} + \frac{1}{280}\right)^{-1} = 69.53$$

$$i_{eq} = \frac{5}{44 + 69.53} = 44.04$$

$i = (44.04 \cdot 10^{-3})\left(\frac{280}{280+92.5}\right) = 33.10\,mA$

$i_o = (33.1 \cdot 10^{-3})\left(\frac{20}{280}\right) = 8.275\,mA$

b) $i_1 = i\left(\frac{140}{140+56}\right) = 23.64\,mA$

$i_{80\Omega} = (44.04 \cdot 10^{-3}) - (23.64 \cdot 10^{-3}) = 20.4\,mA$

$i_{20\Omega} = (8.275 \cdot 10^{-3}) - (23.64 \cdot 10^{-3}) = -15.365\,mA$

$i_Z = 20.4\,mA - (-15.365) = 35.765\,mA$

$P = 5(44.04 \cdot 10^{-3}) = 0.2202W$

9) a) $R_a = \frac{3R^2}{R} = 3R$

$R_b = \frac{3R^2}{R} = 3R$

$R_c = \frac{R^2}{R} = 3R$

$R_{1b} = \frac{\frac{9R_L^3 + 2.25R_L^2}{4R_L}}{\frac{3R_L^2 + 15R_L^2}{4R_L}} = R_L$

b) $i_o = \frac{i_1(3R_L)}{3R_L + 0.75R_L + 0.75R_L} = \frac{i_1}{1.5}$

$V_o = (0.75R_L)(i_0) = \frac{1}{2}V_i \qquad \frac{V_o}{V_i} = 0.5$

16) a) $V_a = \frac{V_{in} R_4}{R_0 + R_4 + \Delta R}$

$V_b = \frac{R_3}{R_2 + R_3} V_{in}$

$V_o = V_a - V_b$

$\frac{R_4}{R_0 + R_4} = \frac{R_3}{R_2 + R_3}$

$V_o = \frac{-\Delta R R_4}{(R_0 + R_4)^2} V_{in}$

b) $\Delta R = 0.03 R_0$

$R_0 = \frac{R_2 R_4}{R_3} = 10000\,\Omega$

$\Delta R = 0.03(10000) = 300\,\Omega$

$V_o = \frac{-(300)(500)}{(15500)^2} \cdot 6 = -8.1\,mV$

c) $V_o = \frac{-(300)(500)}{(15300)(15000)} \cdot 6 = -7.9\,mV$