

Homework III

Ch. 3: 2, 5, 6, 7, 9, 11, 12, 17, 72, 74

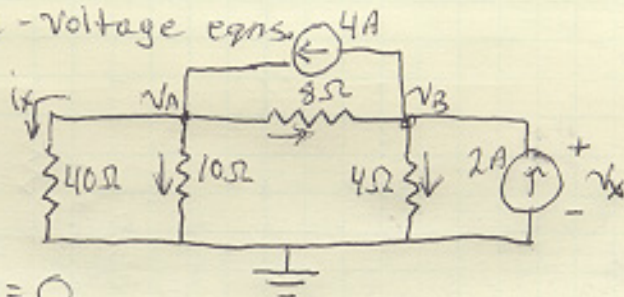
use nodal analysis

P. 3.2

- a) formulate node-voltage eqns.
b) find v_x & i_x .

$$i_x = \frac{1}{40} v_A$$

$$v_x = v_B$$



$$\textcircled{A} \quad \frac{1}{40} v_A - \frac{1}{10} v_A - \frac{1}{8} (v_A - v_B) + 4A = 0$$

$$\left(\frac{1}{40} + \frac{1}{10} + \frac{1}{8}\right) v_A - \frac{1}{8} v_B = 4$$

$$\textcircled{B} \quad \frac{1}{8} (v_A - v_B) - \frac{1}{4} v_B - 4A + 2A = 0$$

$$\frac{1}{8} v_A - \left(\frac{1}{8} + \frac{1}{4}\right) v_B = 2$$

$$v_A = 16V$$

$$v_B = 0$$

$$v_x = v_B = 0$$

$$i_x = \frac{1}{40} v_A$$

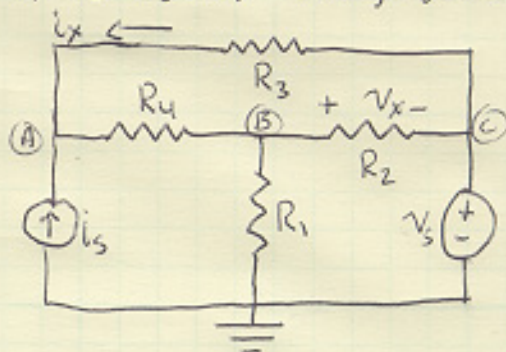
$$i_x = \frac{2}{5} A = 0.4 A$$

P. 3.5

- a) formulate node-voltage eqns.
b) find v_x & i_x for when $R_1 = R_2 = R_3 = R_4 = 10k\Omega$, $v_s = 20V$, $i_s = 2mA$

by inspection

$$\begin{array}{ccc} \textcircled{A} & \textcircled{B} & \textcircled{C} \\ \begin{bmatrix} \frac{1}{R_3} + \frac{1}{R_4} & -\frac{1}{R_4} & -\frac{1}{R_3} \\ -\frac{1}{R_4} & \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_4} & -\frac{1}{R_2} \\ -\frac{1}{R_3} & -\frac{1}{R_2} & \frac{1}{R_2} + \frac{1}{R_3} \end{bmatrix} & \begin{bmatrix} v_A \\ v_B \\ v_C \end{bmatrix} & = \begin{bmatrix} i_s \\ 0 \\ 0 \end{bmatrix} \end{array}$$



$$v_C = v_s$$

$$\begin{bmatrix} \frac{1}{R_3} + \frac{1}{R_4} & -\frac{1}{R_4} \\ -\frac{1}{R_4} & \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_4} \end{bmatrix} \begin{bmatrix} v_A \\ v_B \end{bmatrix} = \begin{bmatrix} i_s + \frac{1}{R_3} v_s \\ \frac{1}{R_2} v_s \end{bmatrix}$$

$$v_A = 28V$$

$$v_B = 16V$$

$$v_x = v_B - v_s$$

$$v_x = -4V$$

$$i_x = \frac{1}{R_3} (v_C - v_A)$$

$$i_x = -0.8 mA$$

P.3.6

- a) formulate node-voltage eqns.
b) find V_x & i_x when $R_1 = R_2 = R_3 = R_4 = R_5 = 10\text{ k}\Omega$, $V_s = 20\text{ V}$

$$\begin{bmatrix} \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} & -\frac{1}{R_2} - \frac{1}{R_3} \\ -\frac{1}{R_2} - \frac{1}{R_3} & \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_5} \end{bmatrix} \begin{bmatrix} V_A \\ V_B \end{bmatrix} = \begin{bmatrix} \frac{1}{R_1} V_s \\ 0 \end{bmatrix}$$

$$V_A = 7.5\text{ V}$$

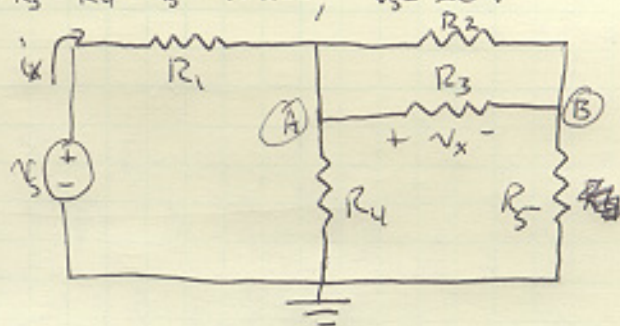
$$V_B = 5\text{ V}$$

$$V_x = V_A - V_B$$

$$V_x = 2.5\text{ V}$$

$$i_x = \frac{1}{R_1} (V_s - V_A)$$

$$i_x = 1.25\text{ mA}$$



P.3.7

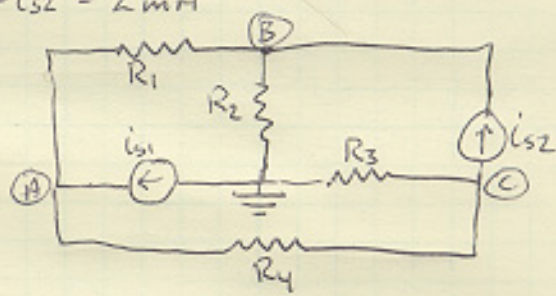
- a) formulate node-voltage eqns.
b) solve for V_A , V_B & V_C when $R_1 = 1\text{ k}\Omega$, $R_2 = 2\text{ k}\Omega$, $R_3 = 4\text{ k}\Omega$, $R_4 = 2\text{ k}\Omega$ & $i_{s1} = i_{s2} = 2\text{ mA}$

$$\begin{bmatrix} \frac{1}{R_1} + \frac{1}{R_4} & -\frac{1}{R_1} & -\frac{1}{R_4} \\ -\frac{1}{R_1} & \frac{1}{R_1} + \frac{1}{R_2} & 0 \\ -\frac{1}{R_4} & 0 & \frac{1}{R_3} + \frac{1}{R_4} \end{bmatrix} \begin{bmatrix} V_A \\ V_B \\ V_C \end{bmatrix} = \begin{bmatrix} i_{s1} \\ i_{s2} \\ -i_{s2} \end{bmatrix}$$

$$V_A = 4\text{ V}$$

$$V_B = 4\text{ V}$$

$$V_C = 0\text{ V}$$



P.3.9

- a) formulate node-voltage eqns.
b) find V_x & i_x

$$\textcircled{A} \frac{1}{10} (V_A - 12\text{ V}) - \frac{1}{10} (V_A - 8\text{ V}) - \frac{1}{5} V_A = 0$$

$$\left(\frac{1}{10} + \frac{1}{10} + \frac{1}{5} \right) V_A = \frac{12}{10} + \frac{8}{10}$$

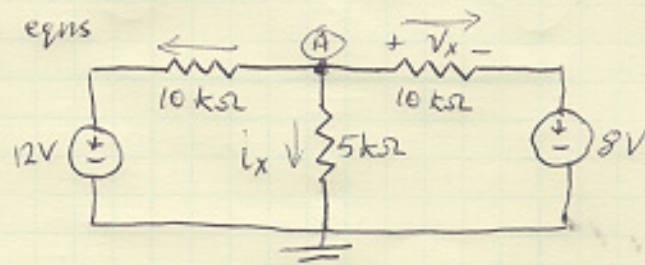
$$V_A = 5\text{ V}$$

$$V_x = V_A - 8\text{ V}$$

$$V_x = -3\text{ V}$$

$$i_x = \frac{1}{5\text{ k}\Omega} V_A$$

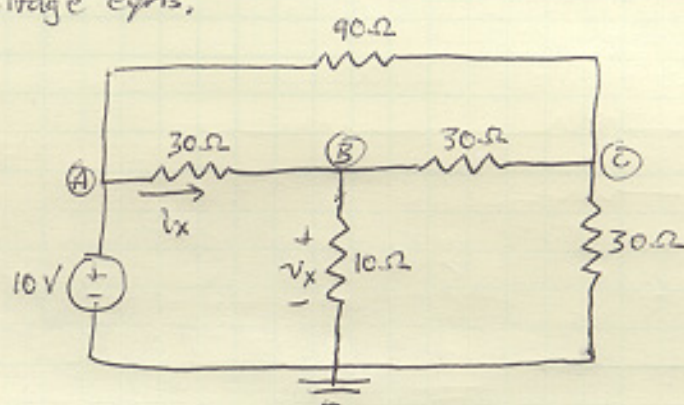
$$i_x = 1\text{ mA}$$



P.3.11 a) formulate node-voltage eqns.
b) find v_x & i_x

$$v_x = v_B$$

$$i_x = \frac{1}{30\Omega} (v_A - v_B)$$



$$\begin{bmatrix} \frac{1}{30} + \frac{1}{90} & -\frac{1}{30} & -\frac{1}{90} \\ -\frac{1}{30} & \frac{1}{30} + \frac{1}{10} + \frac{1}{30} & -\frac{1}{30} \\ -\frac{1}{90} & -\frac{1}{30} & \frac{1}{90} + \frac{1}{30} + \frac{1}{30} \end{bmatrix} \begin{bmatrix} v_A \\ v_B \\ v_C \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

$$v_A = 10V$$

$$\begin{bmatrix} \frac{1}{30} + \frac{1}{10} + \frac{1}{30} & -\frac{1}{30} \\ -\frac{1}{30} & \frac{1}{90} + \frac{1}{30} + \frac{1}{30} \end{bmatrix} \begin{bmatrix} v_B \\ v_C \end{bmatrix} = \begin{bmatrix} \frac{1}{30} v_A \\ \frac{1}{90} v_A \end{bmatrix}$$

$$v_B = 2.5V$$

$$v_C = 2.5V$$

$$\begin{aligned} v_x &= v_B \\ \boxed{v_x = 2.5V} \end{aligned}$$

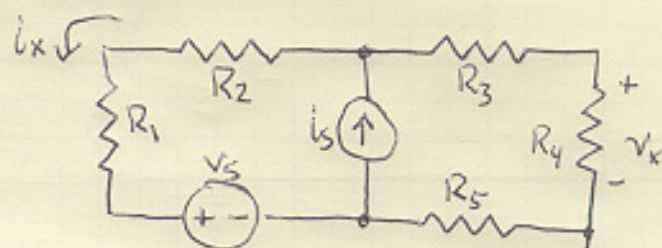
$$\begin{aligned} i_x &= \frac{1}{30\Omega} (v_A - v_B) \\ \boxed{i_x = \frac{1}{4}A = 0.25A} \end{aligned}$$

P. 3.12

a) formulate node voltage eqns.

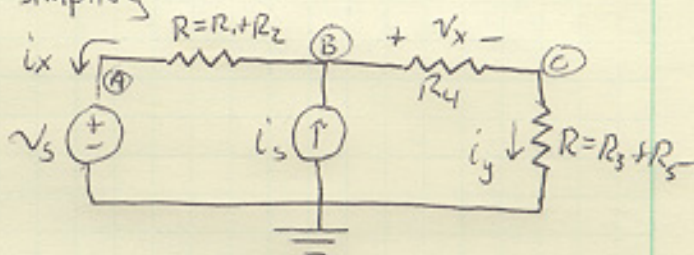
b) find v_x & i_x when $R_1 = 200\Omega$, $R_2 = 300\Omega$, $R_3 = 50\Omega$, $R_4 = 250\Omega$, $R_5 = 200\Omega$, $i_s = 50\text{mA}$, & $v_s = 15\text{V}$

c) find the total power dissipated in the circuit



$$\begin{bmatrix} \frac{1}{R_1+R_2} & -\frac{1}{R_1+R_2} & 0 \\ -\frac{1}{R_1+R_2} & \frac{1}{R_1+R_2} + \frac{1}{R_4} & -\frac{1}{R_4} \\ 0 & -\frac{1}{R_4} & \frac{1}{R_4} + \frac{1}{R_3+R_5} \end{bmatrix} \begin{bmatrix} v_A \\ v_B \\ v_C \end{bmatrix} = \begin{bmatrix} 0 \\ i_s \\ 0 \end{bmatrix}$$

simplify



$$v_A = v_s$$

$$\begin{bmatrix} \frac{1}{R_1+R_2} + \frac{1}{R_4} & -\frac{1}{R_4} \\ -\frac{1}{R_4} & \frac{1}{R_4} + \frac{1}{R_3+R_5} \end{bmatrix} \begin{bmatrix} v_B \\ v_C \end{bmatrix} = \begin{bmatrix} \frac{v_s}{R_1+R_2} + i_s \\ 0 \end{bmatrix}$$

$$v_A = 15\text{V}, \quad v_B = 20\text{V}, \quad v_C = 10\text{V}$$

$$v_x = v_B - v_C$$

$$\boxed{v_x = 10\text{V}}$$

$$i_x = \frac{1}{R_1+R_2} (v_B - v_A)$$

$$\boxed{i_x = 10\text{mA}}$$

$$i_y = \frac{1}{R_4} v_x = 40\text{mA}$$

$$P = i_x^2 (R_1+R_2) + i_y^2 (R_3+R_4+R_5) + v_s i_x$$

$$\boxed{P = 1\text{W}}$$

P.3.17 When node B is grounded $V_C = -2V$.
Find node voltages V_A & V_D & mesh currents i_A & i_B when all resistors are $1k\Omega$

$$V_A - V_D = 10V$$

node C

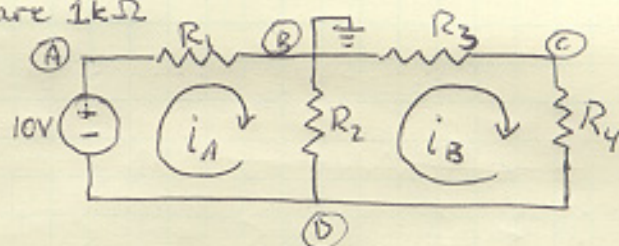
$$i_4 - i_3 = 0$$

$$\frac{1}{R_4}(V_D - V_C) - \frac{1}{R_3}V_C = 0$$

$$V_D = -4V$$

$$V_A = 10V + V_D$$

$$V_A = 6V$$



$$i_A = \frac{1}{R_1}(V_A - V_B)$$

$$i_A = 6mA$$

$$i_B = \frac{1}{R_3}(V_B - V_C)$$

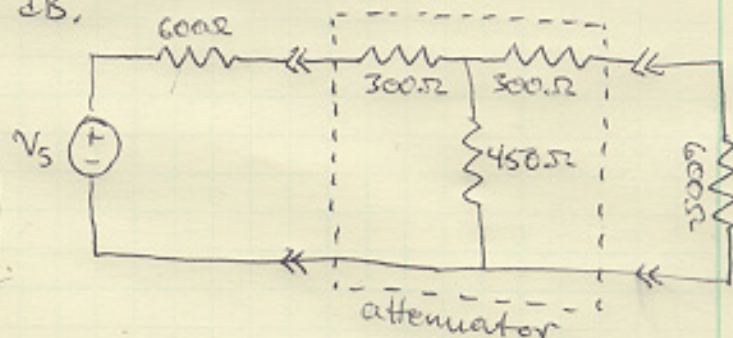
$$i_B = 2mA$$

P.3.72 Find the power delivered to the load with & without the attenuator. By what fraction does the power attenuator reduce the power delivered to the load? Express the fraction in dB.

w/out attenuator

$$V_L = \frac{600}{600+600} V_s = \frac{V_s}{2}$$

$$P = \frac{V_L^2}{R_L} = \left(\frac{V_s}{2}\right)^2 \frac{1}{600} = \frac{V_s^2}{2400} W$$



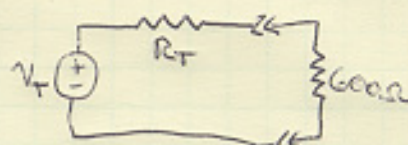
w/attenuator

$$V_T = \frac{450}{600+300+450} V_s = \frac{V_s}{3}$$

$$R_T = 300 + \frac{450(600+300)}{450+600+300} = 600 \Omega$$

$$V_L = \frac{600}{600+600} V_T = \frac{V_s}{6}$$

$$P = \frac{V_L^2}{R_L} = \left(\frac{V_s}{6}\right)^2 \frac{1}{600} = \frac{V_s^2}{21600} W$$

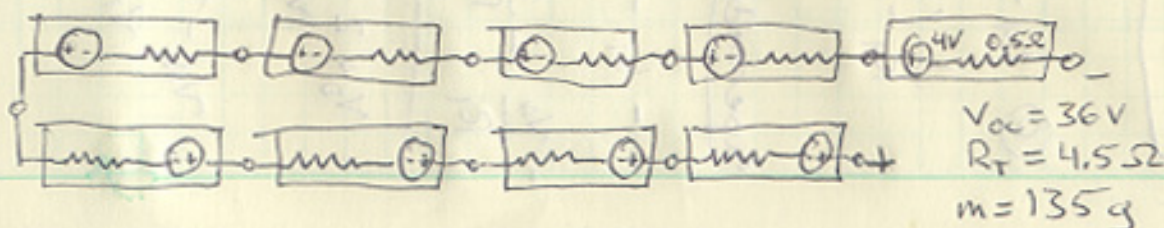


Thevenin equiv. to attenuator circuit

$$\frac{P_{w/out}}{P_{w/}} = \frac{1}{9}$$

$$10 \log \left[\frac{P}{P} \right] = 9.54 \text{ dB}$$

P.3.74



$$V_{oc} = 36V$$

$$R_T = 4.5 \Omega$$

$$m = 135 g$$