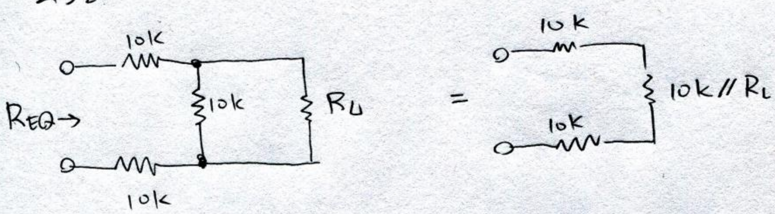
2.32

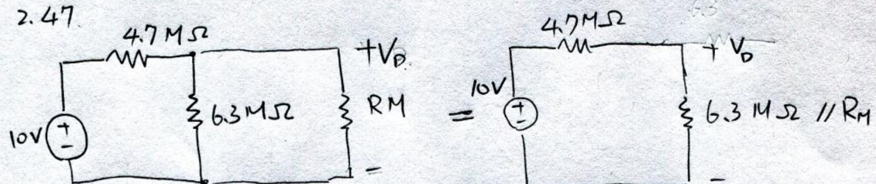


$$R_{eq} = 10 + 10 + 10 /\!/ R_L = 20 + \frac{10 \cdot R_L}{10 + R_L} \quad (k\Omega)$$

For $R_{eq} = 25\ k\Omega$ $\Rightarrow$ $20 + \frac{10 R_L}{10 + R_L} = 25$. $R_L = 10\ (k\Omega)$

For $R_{eq} = 20\ k\Omega$ $\Rightarrow$ $20 + \frac{10 R_L}{10 + R_L} = 20$ $R_L = 0$ (short wire).

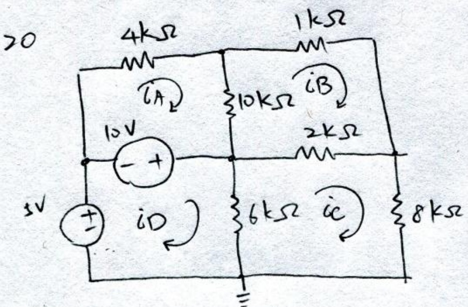
2.47



Applying formula for voltage divider:

$$V_D = 10 \cdot \frac{6.3 /\!/ R_M}{4.7 + 6.3 /\!/ R_M} = \frac{63\ R_M}{29.61 + 11 R_M} = 3.81 \Rightarrow R_M = 5.3492\ (M\Omega)$$

3.20



KVL of Loop A: $i_A \cdot 4k + (i_A - i_B) \cdot 10k = -10$

" " B: $i_B \cdot 1k + (i_B - i_A) \cdot 10k + (i_B - i_C) \cdot 2k = 0$

C: $i_C \cdot 8k + (i_C - i_B)\, 2k + (i_C - i_D) \cdot 6k = 0$

D: $(i_D - i_C) \cdot 6k = 15$

$$1000 \times \begin{bmatrix} 14 & -10 & 0 & 0 \\ -10 & 13 & -2 & 0 \\ 0 & -2 & 16 & -6 \\ 0 & 0 & -6 & 6 \end{bmatrix} \begin{bmatrix} i_A \\ i_B \\ i_C \\ i_D \end{bmatrix} = \begin{bmatrix} -10 \\ 0 \\ 0 \\ 15 \end{bmatrix} \Rightarrow$$

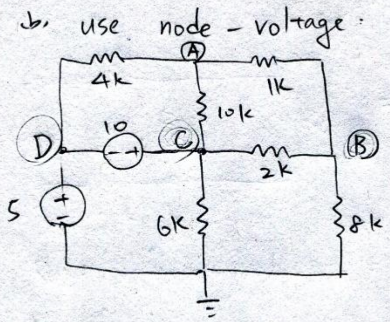
$i_A = -1.2561$ mA

$i_B = -0.7592$ mA

$i_C = 1.3482$ mA

$i_D = 3.8482$ mA.

b. use node - voltage:



By observation, $V_D = 5$. $V_C = 15$

KCL @ A: $\frac{1}{4}(V_A - V_D) + \frac{1}{10}(V_A - V_C) + \frac{1}{1}(V_A - V_B) = 0$

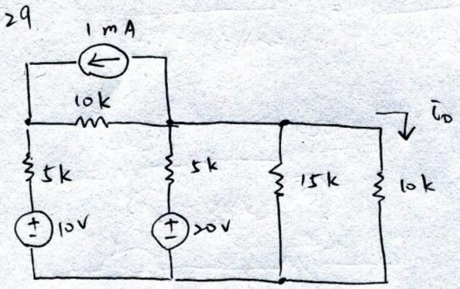
KCL @ B: $\frac{1}{1}(V_B - V_A) + \frac{1}{2}(V_B - V_C) + \frac{1}{8}(V_B) = 0$

$$\begin{bmatrix} \frac{1}{4}+\frac{1}{10}+\frac{1}{1} & \frac{-1}{1} & \frac{-1}{10} & \frac{-1}{4} \\ \frac{-1}{1} & \frac{1}{1}+\frac{1}{2}+\frac{1}{8} & \frac{-1}{2} & 0 \end{bmatrix} \begin{bmatrix} V_A \\ V_B \\ V_C \\ V_D \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix} \quad \& \; V_C = 15, \quad V_D = 5$$

Solve the equation we get: $V_A = 10.0762$ (V) $V_B = 10.7853$ (V)

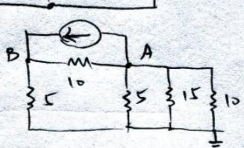
It's easier to solve this circuit using Node-Voltage because with grounded voltage source there will be only 2 unknowns left to be solved.

3.29



Use node voltage.

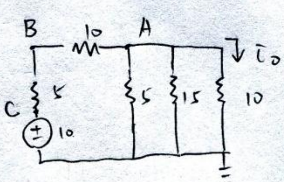
1 mA source on:



$$\begin{bmatrix} \frac{1}{10}+\frac{1}{5}+\frac{1}{15}+\frac{1}{10} & \frac{-1}{10} \\ \frac{-1}{10} & \frac{1}{10}+\frac{1}{5} \end{bmatrix} \begin{bmatrix} V_A \\ V_B \end{bmatrix} = \begin{bmatrix} -1 \text{ mA} \\ 1 \text{ mA} \end{bmatrix}$$

$\Rightarrow V_A = -1.5385$, $i_o = \frac{V_A}{10} = -0.15385$

10V source on:



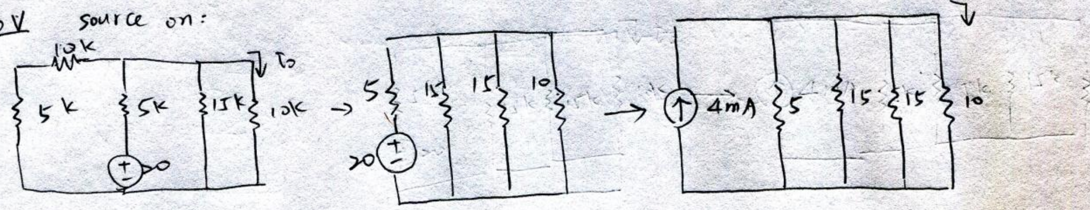
$$\begin{bmatrix} \frac{1}{10}+\frac{1}{5}+\frac{1}{15}+\frac{1}{10} & -\frac{1}{10} & 0 \\ \frac{-1}{10} & \frac{1}{10}+\frac{1}{5} & \frac{-1}{5} \end{bmatrix} \begin{bmatrix} V_A \\ V_B \\ V_C \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

$V_C = 10$

(cont.)

Solve equation we get : $V_A = 1.5385$. $i_0 = \frac{V_A}{10} = 0.15385$

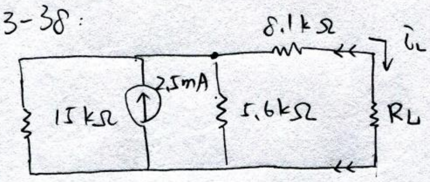
20V source on:



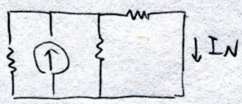
$$i_0 = 4mA \cdot \frac{1/10}{1/5 + 1/15 + 1/15 + 1/10} = 0.9231$$

$$\sum i_0 = -0.1538 + 0.1538 + 0.9231 = \underline{0.9231 \text{ (mA)}}$$

3-38:

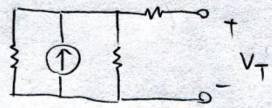


Short circuit : to find I_N



$$I_N = 2.5 \cdot \frac{1/8.1}{1/8.1 + 1/5.6 + 1/15} = 0.8371 \text{ (mA)}$$

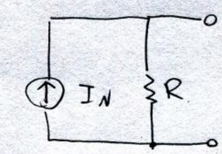
Open circuit : to find V_T



$$V_T = 2.5 \cdot \frac{15 \cdot 5.6}{15 + 5.6} = 10.194 \text{ (V)}$$

$$R = \frac{V_T}{I_N} = 12.178 \text{ (k}\Omega)$$

Norton equivalent seen by R_L:



where $I_N = 0.8371$ mA

$R = 12.178$ kΩ

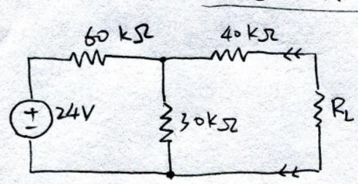
For $R_L = 4.7$ kΩ. Apply formula for current divider:

$$i_L = I_N \cdot \frac{1/R_L}{1/R_L + 1/R} = 0.604 \text{ (mA)}$$

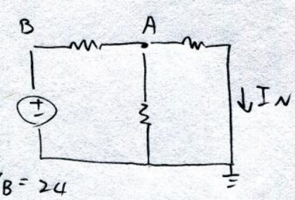
For $R_L = 15$ kΩ, $i_L = 0.3751$ (mA)

$R_L = 68$ kΩ, $i_L = 0.1271$ (mA) ✱

3-39



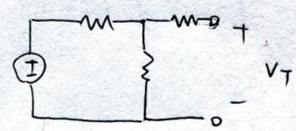
Short circuit to find I_N :



$$\left(\frac{1}{60} + \frac{1}{40} + \frac{1}{30}\right) V_A - \frac{1}{60} V_B = 0 \qquad V_B = 24$$

$$\Rightarrow V_A = 5.3 \qquad I_N = \frac{V_A}{40\text{ k}} = 0.133 \text{ (mA)}$$

Open circuit to find V_T :

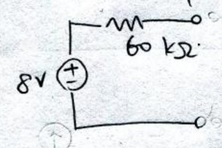


$$\Rightarrow V_T = 24 \cdot \frac{30}{30+60} = 8 \text{ (V)}$$

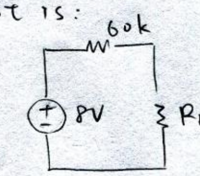
(cont.)

$R = \frac{V_T}{I_N} = 60\ (k\Omega)$

Thévenin equivalent of the circuit is:



connect with R_L:

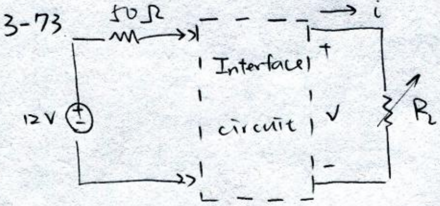


$V_L = 8 \cdot \frac{R_L}{R_L+60}$ $\qquad P = \frac{V_L^2}{R_L} = \frac{64 R_L}{(R_L+60)^2}$

For $R_L = 50\ k\Omega$, $\qquad P = 2.645 \cdot 10^{-4}\ (W)$

For $R_L = 200\ k\Omega$ $\qquad P = 1.893 \times 10^{-4}\ (W)$

3-73



Design Interface circuit using 3 50Ω

let : (1) $V \le 4V$

(2) $i \le 100\ mA$

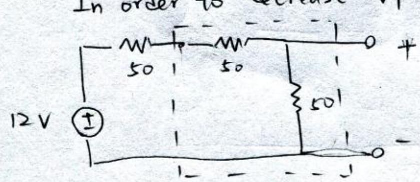
regardless of the value of R_L

i : reach its maximum when $R_L \to 0$

V : reach its maximum when $R_L \to \infty$

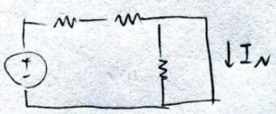
which implies that we need to design one circuit with $\boxed{V_T \le 4V}$ & $\boxed{I_N \le 100mA}$

In order to decrease $V_T \Rightarrow$ use voltage divider with 2 50Ω resistors:



$\Rightarrow V_T = 12 \cdot \frac{50}{150} = 4V$

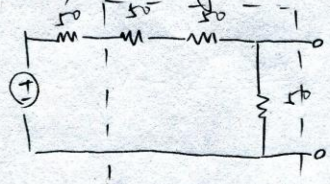
check current:



$I_N = \frac{12}{100} = 0.12 > 100\ mA$.

(fail)

Try voltage devider with 3 more 50 Ω resistors:



$\Rightarrow$

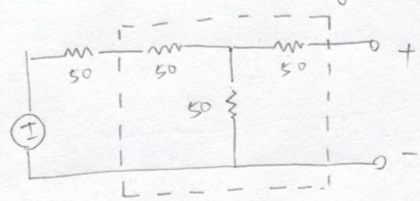
$V_T = 12 \cdot \frac{50}{200} = 3V$, $\quad (\checkmark)$

$I_N = \frac{12}{150} = 0.08 < 100\ mA \quad (\checkmark)$

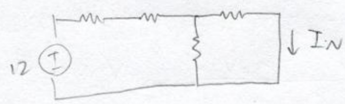
This is a valid design!

(cont.)

Another possible design: Start from voltage divider



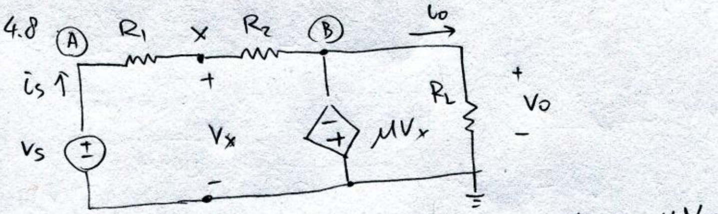
$V_T = 12 \cdot \frac{50}{150} = 4V$ (V)



$I_N = \frac{12}{100+25} \times \frac{1}{2} = 0.048 < 100mA$ (V)

This is also a possible design !

4.8



By setting up ground. $V_A = V_s$. $V_B = -\mu V_x$

KCL @ x : $(V_x - V_A)\cdot\frac{1}{R_1} + (V_x - V_B)\cdot\frac{1}{R_2} = 0$,

$$\Rightarrow V_x = \frac{V_s R_2}{R_1 + R_1\mu + R_2}$$

$i_o = \frac{V_B - 0}{R_L}$, $i_s = \frac{V_x - V_B}{R_2} = \frac{V_x(1+\mu)}{R_2}$ $\frac{i_o}{i_s} = -\frac{\mu}{(1+\mu)}\cdot\frac{R_2}{R_L}$ *

$V_o = V_B = -\mu V_x$ $\frac{V_o}{V_s} = \frac{-\mu R_2}{R_1 + R_1\mu + R_2}$ *

Note: express $\frac{i_o}{i_s}$, $\frac{V_o}{V_s}$, interms of R_1, R_2, μ,