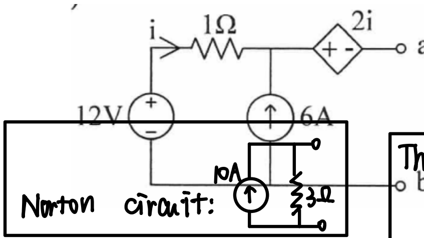
ZJU-UIUC INSTITUTE

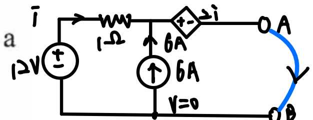
Zhejiang University – University of Illinois at Urbana-Champaign Institute

ECE-210 Analog Signal Processing Spring 2022

Homework #3: Submission Deadline 9th March (10:00 PM)

1. Determine the Thevenin and Norton equivalent circuits equivalent circuits of the following network between nodes a and b, and then determine the available power of the network.

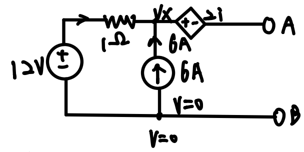


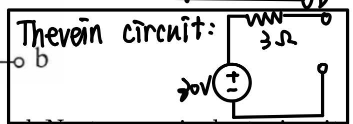


$\Rightarrow 12V - i = 2i$

$\Rightarrow i = 4A$

$\Rightarrow I_{short} = 10A$



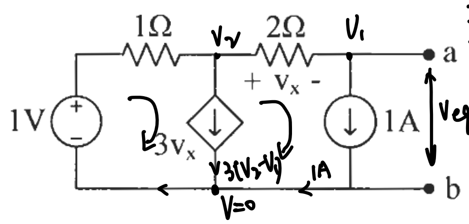


Available pwr: $P = \frac{V^2}{4R} = \frac{(30)^2}{12} = 75W$

$\frac{12-V_x}{1\Omega} + 6A = 0 \Rightarrow V_x = 18V$

$\Rightarrow i = \frac{12-V_x}{1\Omega} = -6A \Rightarrow 2i = -12V \Rightarrow V_{open} = 30V$

2. Determine the Thevenin and Norton equivalent circuits equivalent circuits of the following network between nodes a and b, and then determine the available power of the network.



Ieq $\Rightarrow \frac{1-V_x}{1\Omega} = 3V_x + \frac{V_x}{2}$

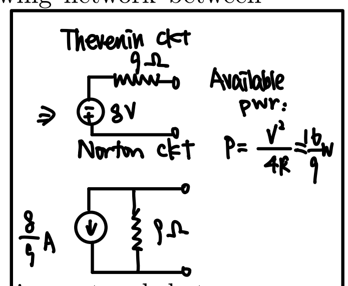
$\Rightarrow 1 - V_x = 3V_x + \frac{V_x}{2}$

$\therefore V_x = \frac{2}{9} V$

$I_{eq} = -\frac{8}{9} A$

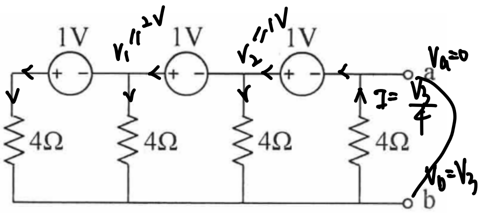
Veq $\Rightarrow \begin{cases} 1A + 3(V_2 - V_1) = (1 - V_2) \\ \frac{V_2 - V_1}{2} + (V_2 - V_1) = (1 - V_2) \end{cases}$

$\Rightarrow \begin{cases} V_1 = -8V \\ V_2 = -6V \end{cases} \Rightarrow V_{eq} = -8V$



Available pwr: $P = \frac{V^2}{4R} = \frac{16}{9} W$

3. Determine the Thevenin and Norton equivalent circuits equivalent circuits of the following network between nodes a and b, and then determine the available power of the network.



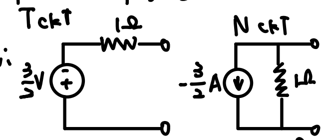
Veq: $\frac{2-V_3}{4} + \frac{3-V_3}{4} = \left(\frac{V_3}{4} - \frac{1-V_3}{4}\right)$

$\Rightarrow \frac{5}{4} - \frac{V_3}{2} = \frac{V_3}{2} - \frac{1}{4}$

$\therefore V_3 = \frac{3}{2} \therefore V_{eq} = -\frac{3}{2} V$

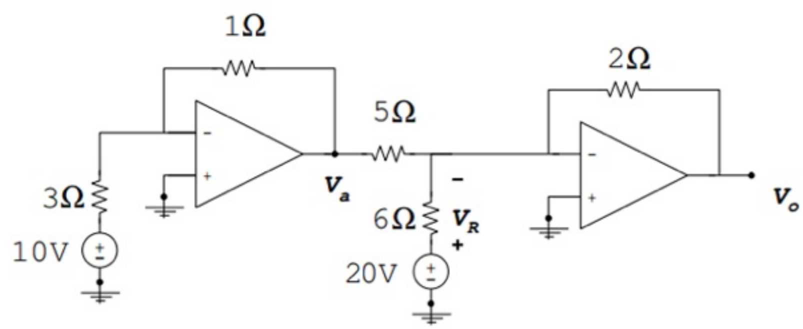
Ieq: $-\left(\frac{1}{4}A + \frac{1}{2}A + \frac{3}{4}A\right) = -\frac{3}{2}A$

$\therefore$



available Pwr: $P = \frac{V^2}{4R} = \frac{\frac{9}{4}}{4} = \frac{9}{16} W$

4. In the op-amp circuit shown below, determine the voltages V_a, V_R, and V_o. Assume the circuit behaves linearly and make use of the ideal op-amp approximation.



① For Va approximation:

$\begin{cases} V_- \approx V_+ = 0 \\ \frac{10V - V_-}{3\Omega} = \frac{V_- - V_a}{1\Omega} \end{cases} \Rightarrow V_a = -\frac{10}{3} V$

② for V_R approximation

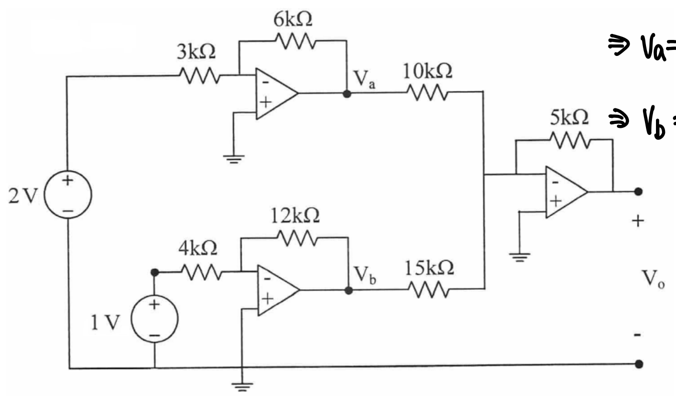
As $V_- \approx V_+ = 0$

then $V_R = 20V$

③ $\frac{V_a}{5} + \frac{20}{6} = \frac{-V_o}{2} \Rightarrow V_o$

$\therefore V_o = -\frac{16}{3} V$

5. In the op-amp circuit shown below, determine the voltages V_a, V_b, and V_o, assuming linear operation and the ideal op-amp approximation.



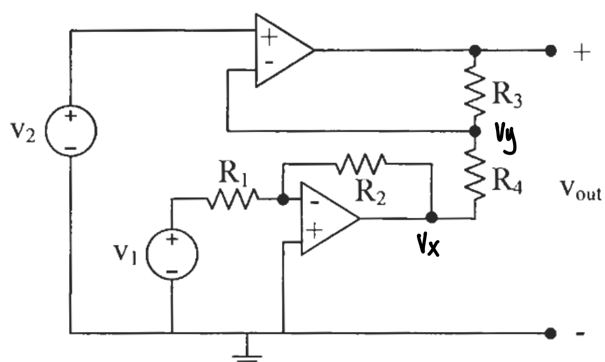
$\Rightarrow V_a = -\frac{2V}{3k\Omega} \times 6k\Omega = -4V$

$\Rightarrow V_b = -\frac{1V}{4k\Omega} \times 12k\Omega = -3V$

$\Rightarrow \frac{-4V}{10k\Omega} + \frac{-3V}{15k\Omega} = \frac{-V_o}{5k\Omega}$

$\therefore V_o = 4 \times \frac{1}{2} + 3 \times \frac{1}{3} = 3V$

6. Consider the circuit below assuming linear operation and the ideal op-amp approximation. Obtain v_{out} in terms of v_1, v_2, R_1, R_2, R_3, and R_4.



$\Rightarrow V_x = -\frac{R_2}{R_1} V_1 \quad V_- \simeq V_+ = V_2$

$\frac{V_2 - V_{out}}{R_3} = \frac{V_x - V_2}{R_4}$

$\Rightarrow V_2\left(\frac{R_3 R_4}{R_3 + R_4}\right) - V_x / R_4 = \frac{V_{out}}{R_3}$

$\therefore V_{out} = \left(1 + \frac{R_3}{R_4}\right) V_2 + \frac{R_3}{R_4} \cdot \frac{R_2}{R_1} V_1$