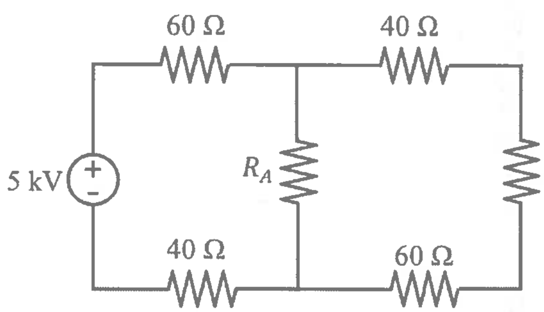
ECSE-200 Electric Circuits 1 - Quiz #7 (Mar. 1, 2019)

LAST NAME SOLUTIONS **MCGILL ID#** ____________

FIRST NAME ____________ **SIGNATURE** ____________

- *Only Faculty standard calculator accepted*
- *No cellphone allowed*
- *Show all your work*
- *Clearly indicate your final answer with the SI unit and multiplier*
- *You have 45 minutes to complete this quiz*

Question 1: Consider the circuit shown below. Answer the following questions.

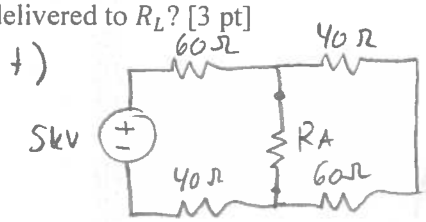


a) Under the condition where $R_L = 0\ \Omega$, what resistance value should R_A be to maximize the power delivered to R_A and what is the maximum power value that can be delivered to R_A? [2 pt]

b) Under the condition where $1/R_A = 0\ \Omega^{-1}$, what resistance value should R_L be to maximize the power delivered to R_L and what is the maximum power value that can be delivered to R_L? [2 pt]

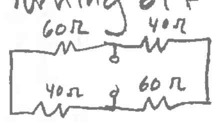
c) Under the same condition where $1/R_A = 0\ \Omega^{-1}$, but with the constraint that the current through R_L must be at least 15 A, what resistance value should R_L be to maximize the power delivered to R_L and what is the maximum power value that can be delivered to R_L? [3 pt]

a) $R_L = 0\Omega$ (short circuit)



→ MAX PWR TRANSFER THEOREM where RA = RT

Turning off supply.



$R_T = (60+40)//(40+60)$

$R_T = 50\Omega$

$\boxed{\therefore R_A = 50\Omega}$

MAX PWR:

$P_{wr} = \frac{V_{oc}}{2} \cdot \frac{i_{sc}}{2}$

$P_{wr} = \frac{2.5kV}{2} \cdot \frac{50A}{2}$

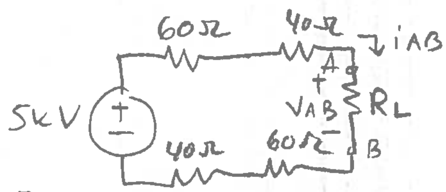
$\boxed{P_{wr} = 31.25\ kW}$

$V_{oc} = 5kV \cdot \frac{(40\Omega+60\Omega)}{60\Omega+40\Omega+40\Omega+60\Omega}$

$V_{oc} = 5kV \cdot \frac{100\Omega}{200\Omega} = 2.5kV$

$i_{sc} = \frac{V_{oc}}{R_T} = \frac{2.5kV}{50\Omega} = 50A$

b) $\frac{1}{R_A} = 0\Omega^{-1} \rightarrow R_A = \infty$ (open circuit)



$R_L = R_T$ for max pwr

$R_T = 200\Omega$ $\boxed{\therefore R_L = 200\Omega}$

$P_{wr} = \frac{V_{oc}}{2} \cdot \frac{i_{sc}}{2}$

$= \frac{5kV}{2} \cdot \frac{25A}{2}$

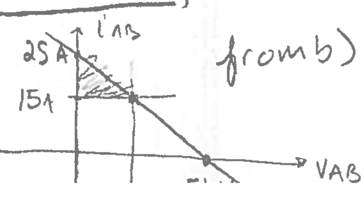
$\boxed{P_{wr}: 31.25\ kW}$

$V_{oc} = 5kV$

$i_{sc} = \frac{V_{oc}}{R_T} = \frac{5kV}{200} = 25A$

$\boxed{\begin{array}{l} \therefore R_L = 133\tfrac{1}{3}\Omega \\ \therefore P_{wr}: 30kW \end{array}}$

c) $i_{AB} \geq 15A$



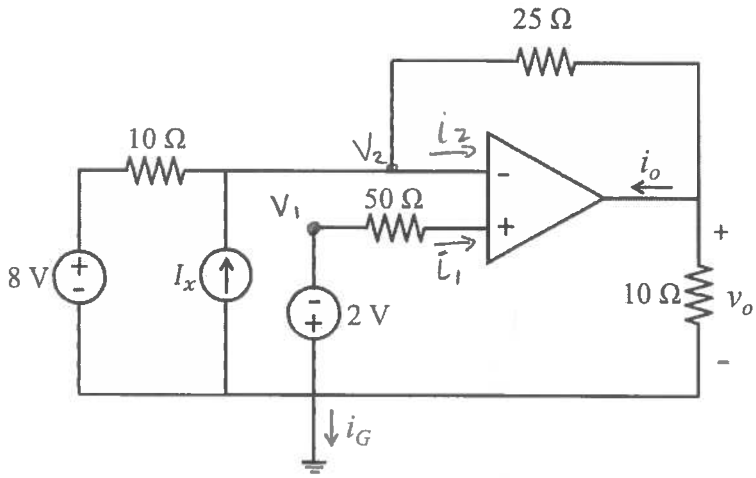
from b)

MAX power at $i_{AB} = 15A$

$V_{AB} = 5kV - 15A \cdot 200\Omega = 2kV$

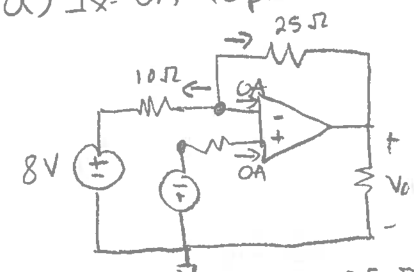
$R_L = \frac{V_{AB}}{i_{AB}} = \frac{2kV}{15A} = 133\tfrac{1}{3}\ \Omega$

Question 2: Consider the circuit shown below. Answer the following questions.



a) Under the condition where $I_x = 0\ A$, what is the voltage value v_0? [2 pt]
b) Under the condition where $I_x = 1\ A$, what is the current value i_0? [2 pt]
c) Under the condition where $I_x = 2\ A$, what is the current value i_G? [2 pt]
d) Under the same condition as in part c) where $I_x = 2\ A$, what is the power delivered by the current source? [1 pt]

a) $I_x = 0A$ (open-circuit)



from ideal opamp model $i_1 = i_2 = 0$ $V_1 = V_2$

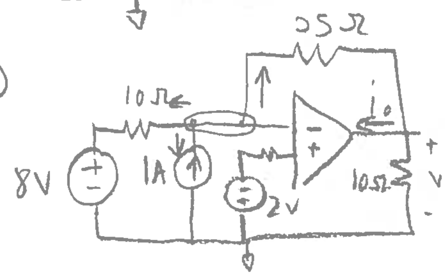
$V_1 = -2V = V_2$

KCL @ inv. node

$$\frac{-2V-8V}{10\Omega} + \frac{-2V-V_o}{25\Omega} = 0$$

$$-1A - \frac{2V}{25\Omega} = \frac{V_o}{25\Omega} \Rightarrow \boxed{V_o = -27V}$$

b)



ideal model $i_1 = i_2 = 0$ & $V_1 = V_2 = -2V$

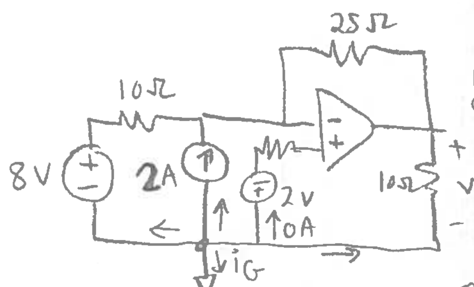
KCL @ inv. node $\rightarrow$ $\frac{-2V-8V}{10\Omega} - 1A + \frac{-2V-V_o}{25\Omega}$

$$-2A - \frac{2V}{25\Omega} = \frac{V_o}{25\Omega} \Rightarrow V_o = -52V$$

KCL @ output node:

$$i_o + \frac{-52-(-2)}{25\Omega} + \frac{-52}{10\Omega} = 0 \rightarrow i_o = 2A + 5.2A \quad \boxed{i_o = 7.2A}$$

c)



find V_o as in b) KCL @ inv. node:

$$\frac{-2V-8V}{10\Omega} - 2A + \frac{-2V-V_o}{25\Omega}$$

$$-3A - \frac{2V}{25\Omega} = \frac{V_o}{25\Omega} \Rightarrow V_o = -77V$$

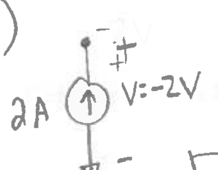
KCL @ ref node

$$\frac{8V-(-2V)}{10\Omega} + 2A + 0A + \frac{-(-77)}{10\Omega} + i_G = 0$$

$$1A + 2A + 7.7A + i_G = 0$$

$$\boxed{\therefore\ i_G = -10.7A}$$

d)



Pwr: -4W (opposite to passive sign conv)

$\boxed{-4W \text{ delivered}}$