EECS 40, Spring 2007
Prof. Chang-Hasnain

Homework #3

Due at 6 pm in 240 Cory on Wednesday, 2/7/07
Total Points: 100

- Put (1) your name and (2) discussion section number on your homework.
- You need to put down all the derivation steps to obtain full credits of the problems. Numerical answers alone will at best receive low percentage partial credits.
- No late submission will be accepted expect those with prior approval from Prof. Chang-Hasnain.

1. Find the Thevenin equivalent circuit with respect to the terminals a, b in the circuit in Fig.1. [10 points]

Computing Isc → [4 points]

Note $V_x = 0$, so we have 5V across the $2k\Omega$ resistor

Thus, $I_x = \dfrac{5V}{2k\Omega} = 2.5mA$

$I_{sc} = 20I_x = 50mA$

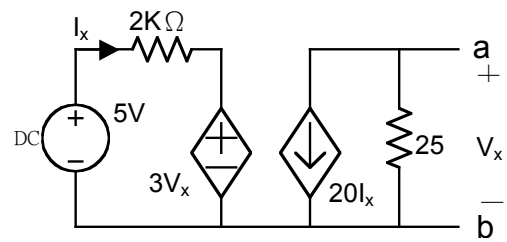


Fig.1

Computing V_{oc} → [4 points]

$$I_x = \frac{5V - 3V_x}{2k\Omega}$$

$$V_x = 25\Omega(-20I_x) = 25\Omega\left(-20\left(\frac{5V - 3V_x}{2k\Omega}\right)\right) = -5V$$

Computing R_{th} → [2 points]

$R_{th} = V_{oc} / I_{sc} = 100\Omega$

2. Find the maximum power that can be delivered to a resistive load by the circuit shown in Fig. 1. For what value of load resistance is the power maximum? [10 points]

Maximum power is delivered to a load when it matches the Thevenin resistance (you can check this with simple derivatives). Thus, the load resistance should be 100Ω.

The power is given by:

$P = V^2 / R = (2.5V)^2 / 100\Omega = 0.0625W$

3. Find the Norton equivalent circuit with respect to the terminals a, b in the circuit shown in Fig.2 [10 points]

Notice that there are no independent sources in the circuit – open circuit voltage and short circuit current are not useful for computing the IV characteristic because both give us the origin. [5 points]

We can apply a test voltage between A and B – in this case, we obtain the following:

$$I_t + \frac{-1.5I_t - V_t}{3\Omega} = \frac{V_t}{2\Omega}$$

$$0.5I_t = V_t\left(\tfrac{1}{2} + \tfrac{1}{3}\right)$$

$$\frac{V_t}{I_t} = \frac{3}{5}\Omega = R_n$$ [5 points]

In other words, the Norton equivalent circuit for Figure 2 is a 0.6Ω resistor.

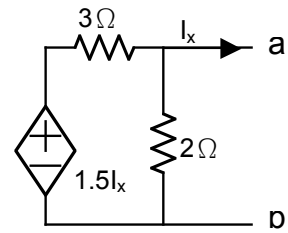


Fig.2

4. Use superposition to find i_1 [10 points: 4 for each part, 2 for combining them]

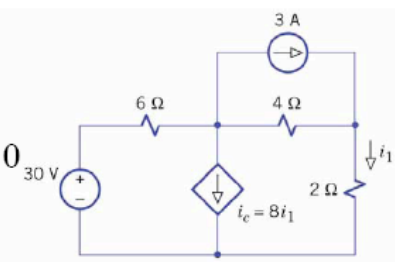
Ex.2.11 use superposition to find i_1

from source 1 of 30V

$KCL \rightarrow 9i_{1-1}$

$KVL \rightarrow 30 - 6(9i_{1-1}) - (4+2)i_{1-1} = 0$

$i_{1-1} = 0.5$



(a) Circuit with a CCCS

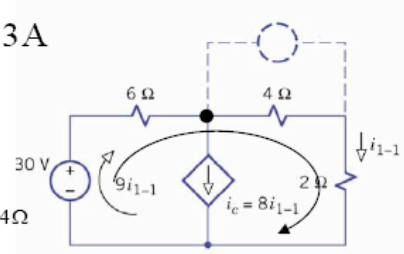
from source 2 of 3A

$KCL \rightarrow 9i_{1-2}$

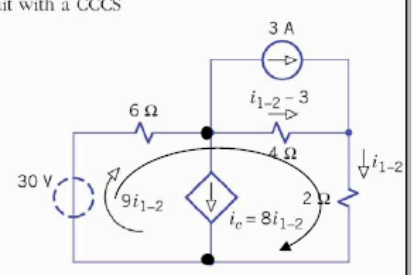
$KCL \rightarrow$

$9i_{1-2} = 8i_{1-2} + 3 + i_{4\Omega}$

$\rightarrow i_{4\Omega} = i_{1-2} - 3$



(b) 30-V source active



(c) 3-A source active

$KVL \rightarrow 6(9i_{1-2}) + 4(i_{1-2} - 3) + 2i_{1-2} = 0$

$\rightarrow i_{1-2} = 0.2$

$i_1 = i_{1-1} + i_{1-2} = 0.7A$

5. Hambley, P2.70 [10 points]

From the information given we can plot two points on an IV plot, and from the slope of the line we can obtain R_{TH}.
At I = 0, V = 20V
At V = 5V, I_{in} = -V/R = -5mA
The slope of the line gives the resistance by:

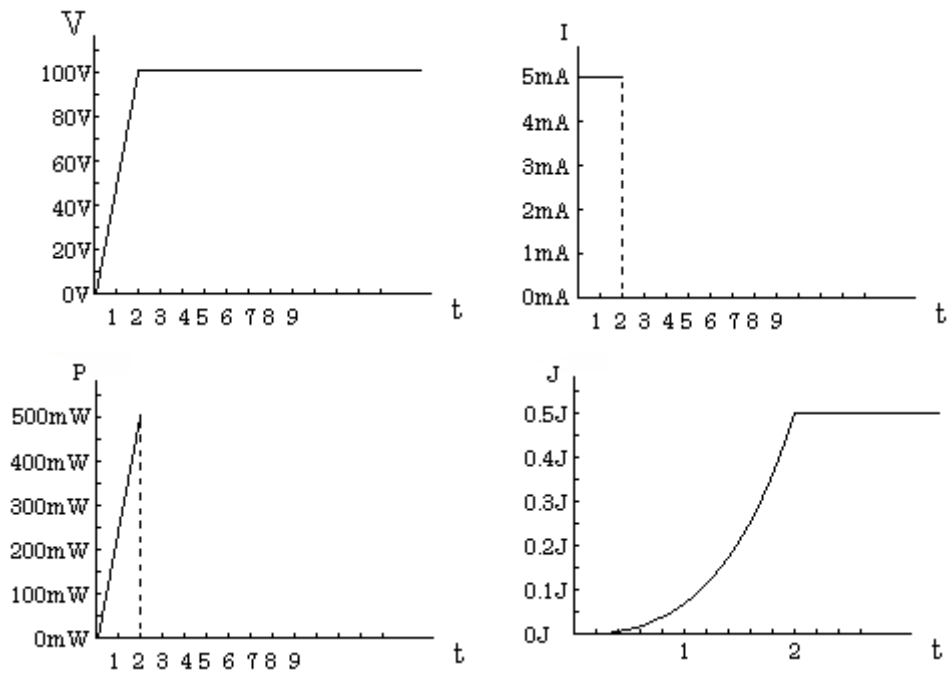
$$R_{th} = \frac{1}{slope} = \frac{20V - 5V}{0mA + 5mA} = 3k\Omega$$

6. Hambley, P2.85 [10 points]

a) With 2A input, I = 2A, so V = 16V. [3 points]
b) With 1A input, I = 1A, so V = 2V. [3 points]
c) With 3A input, I = 3A, so V = 54V. [3 points]
Superposition does not apply in this case because the device's IV characteristics are not linear. [1 point]

7. Hambley, P3.9 [10 points, 2.5 per plot]

Given that current is the rate of change in charge and voltage over a capacitor, we obtain:



8. Hambley, P3.22 [10 points]

Parallel capacitors add like series resistors, and series capacitors add like parallel resistors.
Thus, the equivalent capacitance of the first diagram is given by:
$C_{eq} = (3\mu F + (1\mu F \parallel 2\mu F)) + (2\mu F \parallel (1\mu F + 1\mu F)) = (3\tfrac{2}{3}\mu F + 1\mu F) = 4.67\mu F$ [5 points]
The equivalent capacitance of the second diagram is given by:
$C_{eq} = (2\mu F + 1\mu F) \parallel (4\mu F + 2\mu F) = 2\mu F$ [5 points]

9. Hambley, P3.32 [10 points]

We can think of this system as a set of two parallel capacitors, in which case their capacitances add.
$C_{eq} = \left(\frac{\varepsilon_1 A_1}{d}\right) + \left(\frac{\varepsilon_2 A_2}{d}\right) = \left(\frac{\varepsilon_0 W(100-x)}{d}\right) + \left(\frac{25\varepsilon_0 W x}{d}\right) = (100 - x + 25x)\left(\frac{\varepsilon_0 W}{d}\right)$ [7 points]
We can plug in x=0 and use the initial value to solve for
$\left(\frac{\varepsilon_0 W}{d}\right) = \frac{200pF}{100cm} = 2pF/cm$, which gives us $C_{eq} = (48x + 200)pF$ (where x is in cm).
[3 points]

10. Hambley, P3.45 [10 points]

We know the voltage over an inductor directly controls the rate of change of the current.

$$V = L\frac{\Delta I}{\Delta t}, \frac{\Delta I}{\Delta t} = \frac{10V}{50\mu H} = 0.2MA/s$$

$$t_x = 200mA\left(\frac{\Delta I}{\Delta t}\right)^{-1} = 1\mu s$$