ECE 207 – CONTROLLED SOURCES – INVESTIGATION 6
CIRCUITS WITH CONTROLLED SOURCES – PART II

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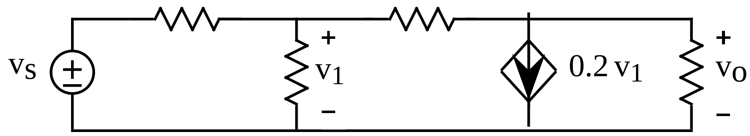
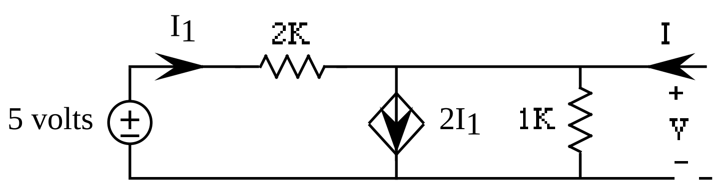
To do "well" on this investigation you must not only get the right answers but must also do neat, complete and concise writeups that make obvious what each problem is, how you're solving the problem and what your answer is. You also need to include drawings of all circuits as well as appropriate graphs and tables.

We know from the last investigation that the voltages and currents in circuits containing controlled sources like the following



are proportional to the **independent** source v_s just like they are in resistor circuits not containing controlled sources. The main objective of this investigation is to calculate the Thevenin Equivalents of such circuits.

1. The objective of this first problem is to illustrate the fact that V and I in circuits containing controlled sources like the following

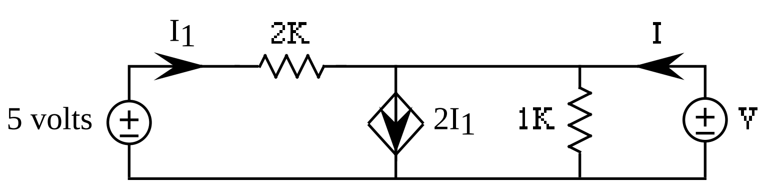


are related by equations of the following form

$$V = 2000I + 3.5$$

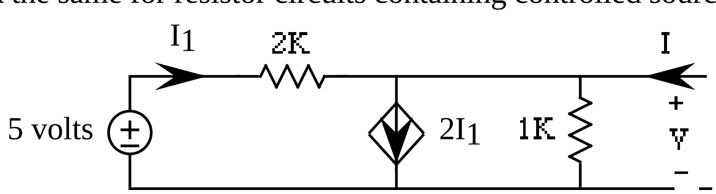
just like they are for resistor circuits containing only independent sources.

Find V as a function of I in this circuit in the usual way - connect a voltage source V as follows



and do the analysis.

2. Generalizing on the result of Problem (1) we can show that not only do the equations for V as a function of I look the same for resistor circuits containing controlled sources



as those not containing controlled sources but resistor circuits with controlled sources also have Thevenin Equivalents. And so we can write

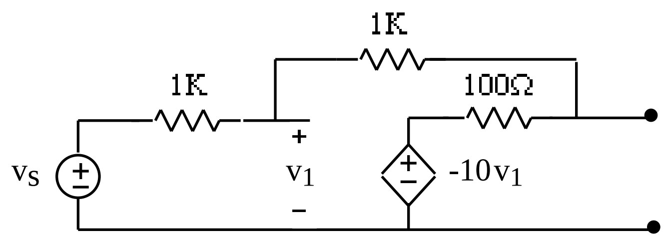
$$V = R_{EQ}I + V_{OC} = R_{TH}I + V_{TH}$$

where

$R_{EQ} = R_{TH}$ = Equivalent Resistance with **all independent** sources set to ZERO
$V_{OC} = V_{TH}$ = Open Circuit Voltage with **all indpendent** sources ON

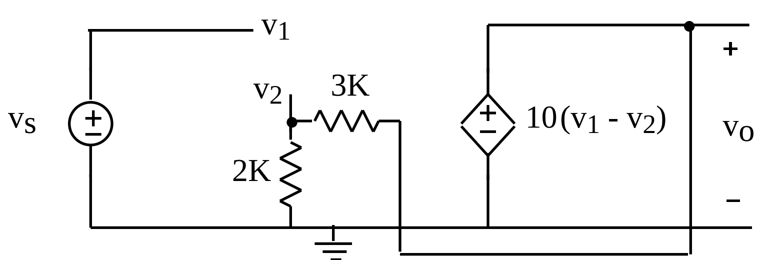
Be sure to note that the controlled sources are **ON** during the calculations of **both** V_{TH} and R_{TH}. **Memorize** this result.

a. Find and then draw the Thevenin Equivalent of the following circuit as seen at the output

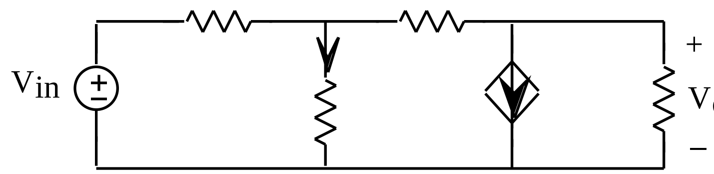


b. Then find v_O when $v_S = 5$ volts and a $R_L = 1K$ load resistor is connected to the output

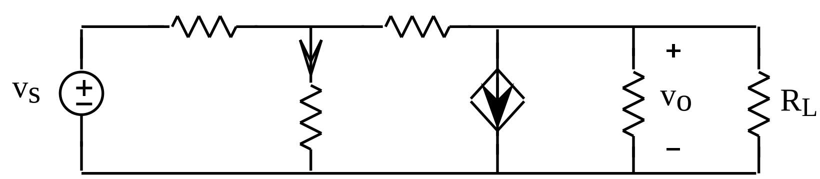
3. Find V_{TH} at the output of the following circuit as a function of v_S



4. The objective of this problem is to illustrate what happens when we connect a load to a circuit containing a controlled source. Suppose we take a resistor circuit containing a controlled source like the following



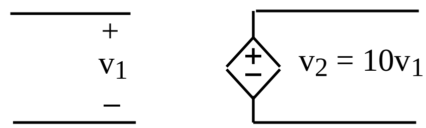
and add a load resistor R_L as follows



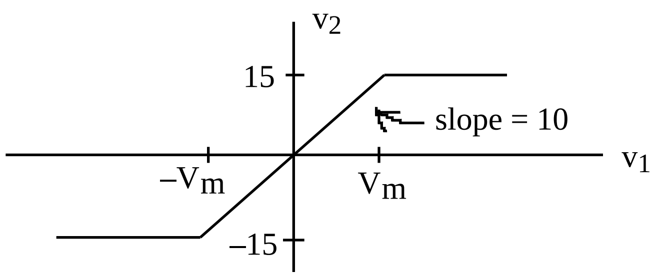
a. What will happen to V_o as a result of R_L being added - will its magnitude go up, go down or stay the same. Make use of Thevenin to justify your result.

b. Sketch V_o as a function of R_L for $V_{TH} = 2$ volts. Describe your curve

5. Up to now all the controlled sources we've been working with have been **ideal** like the following voltage controlled voltage source



with $v_2 = 10\,v_1$ no matter how large v_1 gets. Controlled sources that model "real" circuits, on the other hand, are in fact characterized by curves like the following



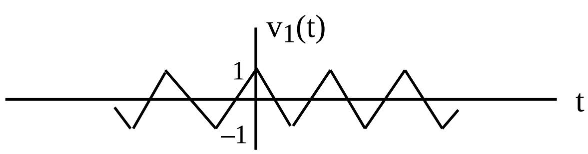
a. Describe how this curve differs from that of an ideal controlled source

b. What is the maximum possible value for v_2

c. What is the value of V_m - the maximum value of v_1 for which our ideal controlled source is a valid model for this "real" controlled source.

d. We say the controlled source is in **saturation** when $v_1 > V_m$ and $v_2 = 15$ volts (and similarly when $v_1 < -V_m$ and $v_2 = -15$ volts). For what values of v_1 is this controlled source in saturation.

e. Sketch $v_2(t)$ if $v_1(t)$ is as follows



f. Sketch $v_2(t)$ if $v_1(t)$ is the same as part (e) except of magnitude 2. Be careful.

6. Math Review - Find and sketch the solution to the following Differential Equation for $t \geq 0$ using the Cookbook method presented in Investigation 4.

$$5x' + 50x = 100 \qquad x(0) = 4$$