

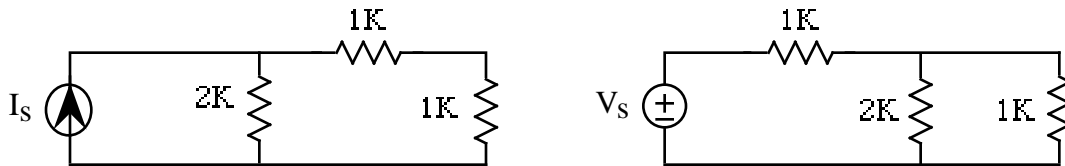
ECE 109 - TRANSFER FUNCTIONS - INVESTIGATION 25 SUPERPOSITION IN RESISTOR CIRCUITS

SUMMER 2007

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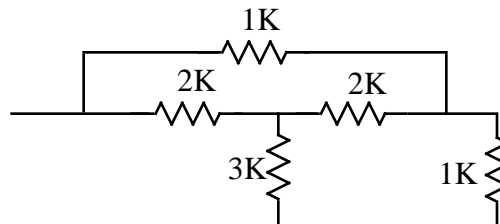
To do "well" on this investigation you must not only get the right answers but must also do neat, complete and concise writeups that make obvious what each problem is, how you're solving the problem and what your answer is. You also need to include drawings of all circuits as well as appropriate graphs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

From our Investigations on transfer functions we know that every voltage and every current in resistor circuits with one source like the following

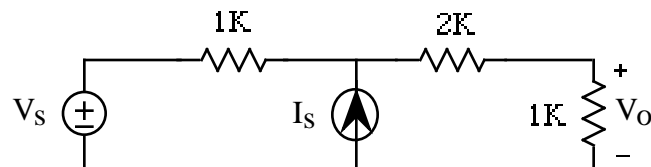


is proportional to the source. The objective of this Investigation is to see what happens when our circuits have more than one source. Be sure to take a look at the **Computer Demos** on Superposition.

1. We begin with a review problem. Find R_{EQ} of the following circuit

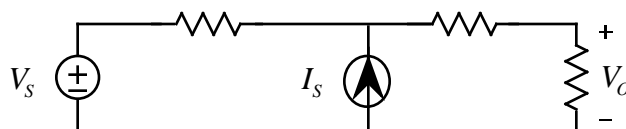


2. Now suppose we have a circuit with two sources as follows



Use node equations to find V_o in terms of the two sources V_s and I_s . Your result should be a sum of two terms - one proportional to V_s and the other to I_s

3. Repeat the analysis of Problem (2) for a circuit that you make up that contains two sources.
4. Generalizing on the results of Problems (2) and (3) it can be shown that every voltage and current in a circuit with two or more sources can be expressed as a sum of terms - each one proportional to one of the sources. V_o in the following circuit, for example



is equal to the following sum of terms

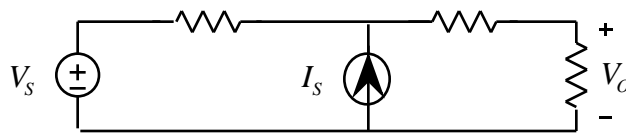
$$V_o = aV_s + bI_s$$

The significance of this expression is that each source's contribution to the output V_o can be calculated independent of the other source. Suppose

$$V_o = 0.7V_s + 1000I_s$$

- What is the contribution of V_s to V_o when $V_s = 5$ volts
- What is the contribution of I_s to V_o when $I_s = 3$ ma
- Make use of your results in parts (a) and (b) to find V_o when $V_s = 5$ volts and $I_s = 3$ ma

5. When the response of a circuit with more than one source like the following



can be expressed as a sum of responses as follows

$$V_o = aV_s + bI_s$$

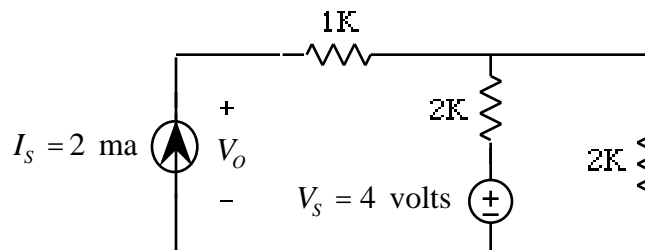
then we say the circuit satisfies **superposition**. We say we are using superposition to obtain V_o when we

- First calculate the response of the circuit to V_s with I_s set to zero
- Then calculate the response of the circuit to I_s with V_s set to zero

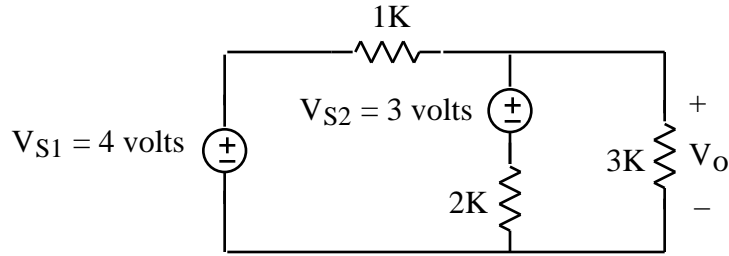
And then add together the two individual responses to obtain the response to when both sources are present. **Memorize** how to analyze a circuit with superposition. Then

- Draw the circuit for calculating the response to V_s - the response with I_s set to zero
- Draw the circuit for calculating the response to I_s - the response with V_s set to zero

6. Use superposition to find V in the following circuit. Keep the bookkeeping straight by letting V_{o1} equal the response to the current source and V_{o2} equal the response to the voltage source. Be sure to **draw** the corresponding circuits with I_s set to zero and V_s set to zero

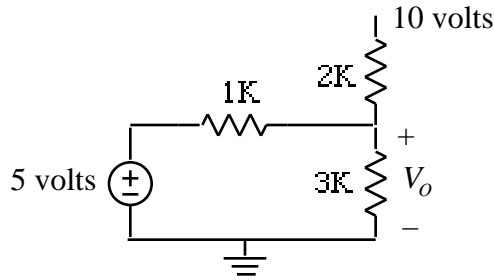


7. Use superposition to find V_o in the following circuit. Be sure to **draw** the corresponding circuits with V_{s1} set to zero and V_{s2} set to zero

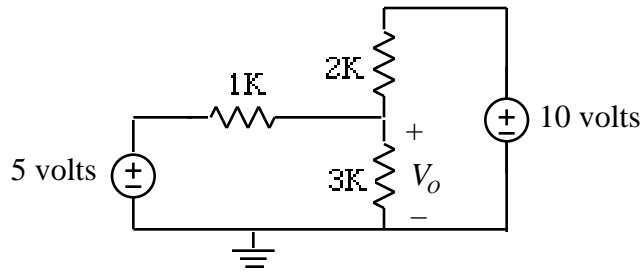


Hint - you can reverse V_{S2} and the 2K resistor without affecting any voltages or currents in the circuit

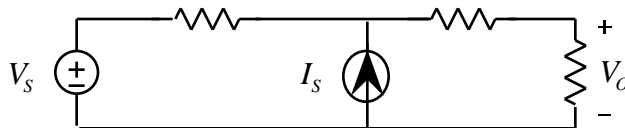
8. Find V_o in Problem (7) without using superposition. Which method was easier
9. How can superposition can be used to find voltages and currents in a circuit with n sources.
10. Use any method you wish to find V_o in the following circuit where



is shorthand for

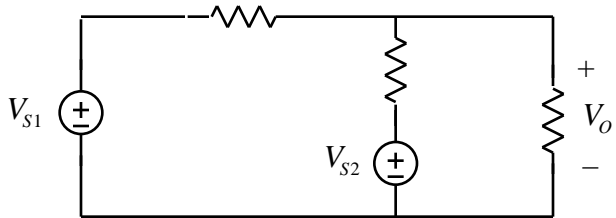


11. Given the following circuit



with $V_o = aV_s + bI_s$. Find a if V_o increases from 2 volts to 3 volts when V_s increases from 3 volts to 5 volts

12. Now suppose we're in the lab and we want to take measurements to obtain the coefficients a and b for the following circuit



with $V_o = aV_{S1} + bV_{S2}$. Since we have two unknowns we need two equations

a. Use the following data to find a and b

V_{S1}	V_{S2}	V_o
3	2	4
1	5	3

b. Now use this data to find a and b

V_{S1}	V_{S2}	V_o
5	0	3
0	4	2

c. For which set of data are the calculations easier.

d. Explain how to obtain the data in part (b) in the lab

13. Math Review: Sketch $x_1(t) = 2\cos(200t + \pi/4)$ and $x_2(t) = 2\cos(200t - \pi/4)$ on the same graph. Identify which is which