Engineering 65 - Circuit Theory

Lab No. 6

“Superposition”

Lab Report By:

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Professor

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TA

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Section

Friday 9:00 am - 11:50 am

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Objective

- Demonstrate comprehension in the principle of superposition through circuit model construction and analysis.
- Mathematically apply conventional equations derived from the principle of superposition for examination.

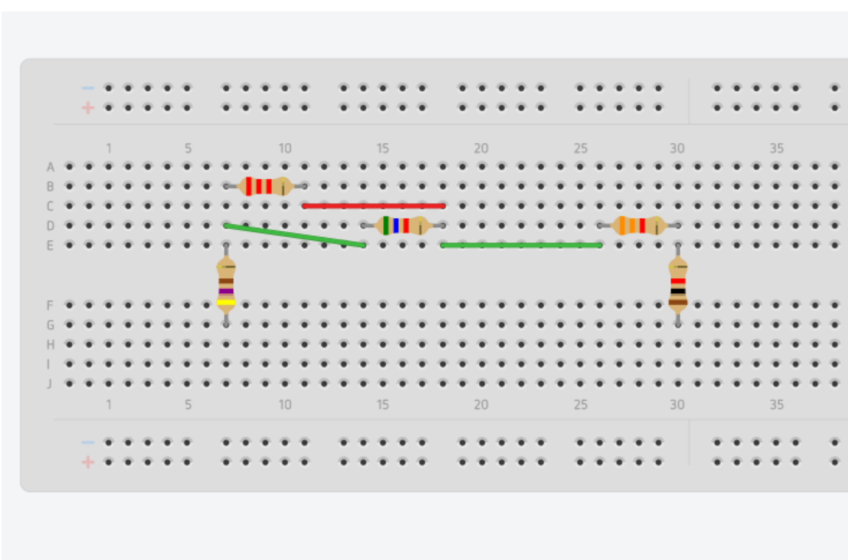
Introduction

The principle of superposition proposes that if two or more power sources are concurrently powering a circuit model, then the current traveling through any other region of the circuit will be the summation of current from the source voltage within the specific branch of the model - thus, neglecting other power sources. Given a complex circuit and if the circuit's elements are linear; more specifically, these components are designed whereas voltage and current are linearly proportional to each other. Through means of employing conventionally derived formulas from the principle of superposition, we may simplify the circuit, and with application of fundamentals such as KCL and KVL will allow for the computation of desired voltage, resistance and current value.

Method and Procedure

The required materials for this lab includes two digital multimeter and power supply, one breadboard, extra wires and connecting cables, and 470 Ohm along with 1, 2.2, 3.3 and 5.6 kilo Ohms resistors for the construction of the circuit model. We lay the breadboard on its slide and used the model as reference; hence, on the right of the board, we have the 470 Ohm resistor running in series to the 2.2 kilo Ohms positioned above it and again laid in series will be 5.6 and 3.3 kilo Ohms resistors leaving the 1 kilo Ohms resistor in series with the 5.6 but parallel to the 470 resistors resistor. Once in the accordance placement, connecting wires are employed to link resistors together. The 470 terminal will be linked with a 5.6 kOhm resistor while the 2.2 kOhm resistor will be wired to the 10 V power source above it. Again, using the connecting wire, link the 5.6 kOhms resistor to the terminal of the 3.3 kOhms resistor. Once done, applied the 15 V power supply to the terminal link of the 5.6 and 3.3 kOhms resistors. Then, by applying the multimeter to the specific joints of the circuit via where the 10 V power source will derive 3.3 mA which is our first current value, then again, applying the multimeter at the second voltage source results in 6.52 mA, and once more, at the 1kOhms terminal will given use the third current value which is 0.707 mA. Repeating the earlier procedure by applying the multimeter to the terminal of 2.2 and the 5.6 kOhms resistors where the 15 V power source is located will give us our first voltage, 2.678 V and the second voltage, 0.780 V. The next procedure of the lab is to remove the 10V power source by short circuiting it.This is done by removing the terminal of the 10 V power source and repeat the same process from the first procedure which will derive the three current values as well as the two voltage variables. The last step is to repeat the second procedure, but this time the 15 V power source will be removed instead and the same measurement method will take place and data will be recorded which will conclude our project.

Recorded Data and Model Representation



	I_1	I_2	I_3	V_1	V_2
Theoretical Value	-3.6183 mA	5.82 mA	0.707 mA	2.679 V	0.71 V
Measured Value	-3.74 mA	5.94 mA	0.63 mA	2.719 V	0.780 V

4. Remove the 10 V source (and replace it with a short circuit). Measure the currents and voltages shown in the circuit.

	I_1	I_2	I_3	V_1	V_2
Theoretical Value	-0.68 mA	3.1 mA	2.92 mA	1.51 V	2.96 V
Measured Value	-0.67 mA	3.11 mA	2.97 mA	1.45 V	2.958 V

5. Place the 10 V source back in the circuit. Remove the 15 V source (and replace it with a short circuit). Repeat step 3.

	I_1	I_2	I_3	V_1	V_2
Theoretical Value	-2.9 mA	2.7117 mA	-2.25 mA	1.27 mA	-2.26 V
Measured Value	-3.06 mA	2.82 mA	-2.34 mA	1.315 V	-2.329 V

Data Summary

The perlab for this lab consists of applying the superposition analysis to first, breakdown the circuit, then apply the rudimentary theorem via KCL, KVL and Ohm's law in order to compute for current and voltage. Therefore, the first step to finding the voltage of the circuit model we still conduct voltage node analysis via KVL at V1, we will derived (v1-10-v2 / 2.2k) + (v1/470) + (v1 - 15)/5.6 K = 0; through algebra simplification, such induces v1 - 0.1645v2 = 2.62. Again, at node v2 will derive the equation (v2+v1+10/220)+(v2-15/3300)+(v2/100) = 0 which simplified will result, v2 = 0.2386v1. Now, by substituting the second derived equation of node v2 into equation one will find v1 as 2.77 V, and now replacing solution for v1 into the second equation will produce v2 as 0.707 V. Then in order to compute for the first current, we should consider the KCL equation which induces that I1= (v1-v2-10)/2200, and considering that both v1 and v2 have been solved for, applied to the equation will produce I1 = -3.62 mA. Next is to compute the second current, consider I2 = V1/470 which equates to I2 = 5.816 mA. Lastly, the third current may be solved by considering I3 = V2/1000 which equates to I3 = 0.707 mA.

The next data set of this lab consists of the voltage and current value as a result of when the 10 V power source is removed from this circuit. For the second part of the lab, we are asked to remove the 15 V power source and consider the principle of superposition. We shall short circuit the model and compute for the three current and two voltage values as done for the previous data set. In this case, circuit analysis shall start from v1, and when applied KVL will yield (v1-v2/2200) +(v1-15/5600)+(v1/470) = =0. Through simplification one carrying v1 out as the common factors and condensation will produce 15.46v1 - 2.545 v2 = 15 - consider this our first equation. Recursive to the previous step, KVL will be applied at v2 which will yield the equation v1 = 3.866 v2 -10 . Combined the two equations will share the product of v1 as 1.45 V and v2 as 2.96 V; recall that in order to find the current of the circuit employ KCL by taking the voltage and divide it by the branch's resistor. Thereby, when 10 V is removed from the circuit, I1 will be -0.684 mA , I2 as 3.102 mA and I3 is 2.963 mA. The last part of the lab will be the same as the previous procedure, yet this time, the 15 V power source will be shorted. Repeating the same approach, by first using KVL to find the voltage, then KCL to find the current, the values for v1 is 1.274 V while v2 is -2.256, I1 is -2.94 mA, I2 is 2.711 mA and I3 will be -2.256 mA.

Comparing the measured values to the measured data recorded from the effort demonstrated within the procedure of this lab, the values are close to each other with error margin nearly neglectable. Evidently, From all three trials with three different circuit models, the principle of superposition is validated, for the current and voltage values are consistent, for when we neglect the voltage power via theoretically or physically short circuiting the model, the measure and mathematically values are closely aligned. Now, there are examples when the recorded measure values are off by a whole 10 % which is within the first trial where no power source is shorted, the value for current three computed via empirical formula is 0.707 mA while the measured value is 0.64 mA. This error could be a derivative of faulty measuring device or faulty circuit wiring, for all other values recorded seem to match up in close proximity - inferring that the large deviation error may be a result of physical components or measuring device. Beyond this shortcoming, the overall data structure recorded is identical with the max error margin at average, 3-4%.

Conclusion

The outcome of this lab consisting of the data presentation through comprehensive circuit model construction and the application of the mathematical proof inspired by principle of superposition has sufficed the declared objective of this session. In summary, the main idea is to acquire the ability to construct a circuit where voltage and current shares a linear relationship, and if there are multiple power source spontaneously running parallely, then theorem of superposition may be applied by neglecting one power source through means of short circuiting while analysis the current and voltage at a desired voltage source, and vice versa for any other power supply that may be introduced to the system. Once the short circuit has been configured whereas mathematically voltage values will simply be ignored, measurement or computation done by application of KVL and KCL will derive desired current and voltage value at chosen reference points.