BME 211 Circuit Analysis Laboratory

Experiment #3: Superposition Principle,

Power Calculations, Power Balancing

Objective

The objective of this experiment is to understand and apply the superposition principle on simple resistive circuits for circuit analysis. Power calculation for voltage supplies and resistors and balancing the total power in a circuit will also be investigated.

Background

1. Superposition

If a circuit has two or more independent sources, one way to determine the value of a specific variable (voltage or current) is to use node-voltage or mesh-current method. Another way is to determine the contribution of each independent source to the variable and then add them up. This approach is known as the superposition. The idea of superposition relies on the linearity property. The superposition principle states that the voltage across (or current through) an element in a linear circuit is the algebraic sum of the voltages across (or currents through) that element due to each independent source acting alone [1].

Steps to apply superposition principle:

a) Turn off all independent sources except one source. Find the output (voltage or current).
b) Repeat step (a) for every other independent sources.
c) Find the total contribution by adding algebraically all the contributions due to the independent sources. [1].

2. Power and Power Calculation

Power, absorbed or supplied by an element, is known as the product of the voltage across the element and the current through it [1].

$$P = vi \qquad \text{(Eq. 3.1)}$$

If the power has a positive sign, power is being delivered to or absorbed by the element. If, on the other hand, the power has a negative sign, power is being supplied by the element.

Current direction and voltage polarity play a major role in determining the sign of power. It is therefore important that we pay attention to the relationship between current i and voltage v. The voltage polarity and current direction must confirm with those shown in Fig 3.1(a). This is known as the passive sign convention. For the passive sign convention, current enters through the positive polarity of the voltage. In this case, $P = vi$ and $v > 0$ implies that the element is absorbing power. However, if $P = -vi$ or $v < 0$, as in Fig. (3.1b), the element is releasing or supplying power.

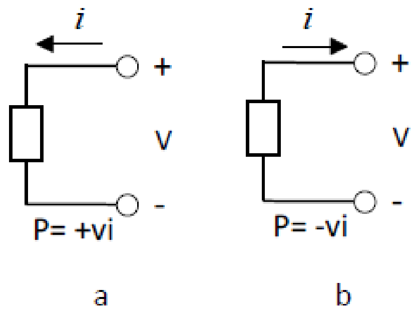

Figure 3.1

Using Ohm’s Law, power for a resistor can be written as:

$$P = i^2R = \frac{v^2}{R}$$

3. Power Balancing

Before starting power balancing we have to understand law of conservation of power. Law of conversation of energy states that, in a closed system, i.e., a system that is isolated from its surroundings, the total energy of the system is conserved. This law must be satisfied in any electric circuit. For this reason, the algebraic sum of power in a circuit, at any instant of time, must be zero:

$$\sum P = 0$$

This again confirms the fact that the total power supplied to the circuit must balance the total power absorbed.

Preliminary Work

1. Calculate the power for all the resistors shown in the figure below and show that the total power is equal to zero.

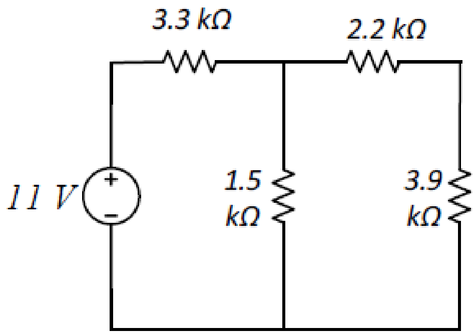

Figure 3.2

2. Determine the value of V_o using Superposition Theorem for the circuit shown in Figure 3.3.

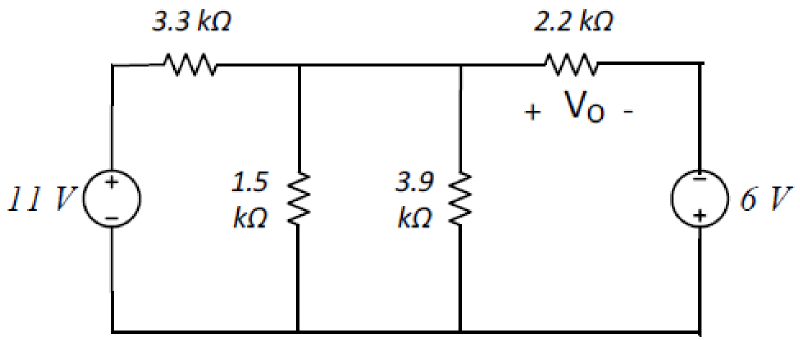

Figure 3.3

Procedure

Before starting, read the laboratory safety instructions on Page 4.

1. a) Set up the circuit in Figure 3.2. Measure the voltage and current for all the components and calculate the power for each component. Compare your results with your calculations in the preliminary work.

   b) Calculate the power supplied/absorbed for each component and comment on the results.

2. Set up the circuit in Figure 3.3. Measure the V_0 for each supply separately and for the case where both supplies are connected. Compare your measurements with your calculations to verify the superposition theroem and comment on the results.

List of Components

Equipments: DC Voltage Supply, Digital Multimeter

Resistors: 1.5 kΩ, 2.2 kΩ, 3.3 kΩ, 3.9 kΩ

References

[1] Alexander K. Charles, Matthew N. O. Sadiku - Fundamentals of Electric Circuits (Tenth Edition)

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Objective

Results

1. Comparison of calculated and measured current values: (Circuit 3.2)

R	$V_{calculated}$	$V_{measured}$	$I_{calculated}$	$I_{measured}$	$P_{calculated}$	$P_{measured}$
3.3kΩ						
2.2kΩ						
1.5kΩ						
3.9 kΩ						

I_{source} (calculated) = ... I_{source} (measured) = ...

P_{source} (calculated) = ... P_{source} (measured) = ...

Comments:

2. a. Voltage measurement for 12V supply: V_{o1} = ... (Circuit 3.3)

Voltage measurement for 6V supply: V_{o2} = ...

Voltage measurement with both supplies: $V_{o,TOTAL}$ = ...

Verification of the superposition theorem, comparison with calculations and comments: