Series Circuits

Air Washington Electronics ~ Direct Current Lab

Series Circuits

Overview

The student is given three separate series resistive circuits. These must first be built in Multisim and on a breadboard by choosing the correct standard value (±5%) resistors. Each activity is progressively more challenging and include additional power supplies (both aiding and opposing) and an additional ground point. Each activity includes a set of measurement points and a question regarding a possible circuit fault. The student must assess the fault and then support that assessment. Student must provide observations and conclusions to demonstrate understanding of concepts.

Requirements

To meet all requirements for this lab, you must complete all activities, questions, critical thinking activities and questions, and observations and conclusions.

Course Objectives

- Use voltage, current, and resistance measurements to isolate defective component or components.
- Demonstrate proper measurement techniques for voltage, current and resistance.
- Demonstrate proper operating techniques and evaluate for proper operation the following list of test equipment: DC Power Supply and Digital Multimeter
- Demonstrate acceptable techniques to construct circuits from schematic drawings on solderless and/or solder type breadboards.
- Demonstrate ability to document a breadboard circuit, schematic, pictorial layouts, predict circuit operation, test circuit operation and compare test results.

Module Objectives

- Choose resistors needed to meet stated specifications using standard resistor values.
- Use electronic simulation software to design a circuit
- Analyze and compare values between simulation and actual circuit.
- Assess circuit fault and support that assessment
- Assess the effect of a series aiding power supply on a series circuit
- Assess the effect of an added ground point on a series circuit
- Analyze voltage potential between various points on the circuit

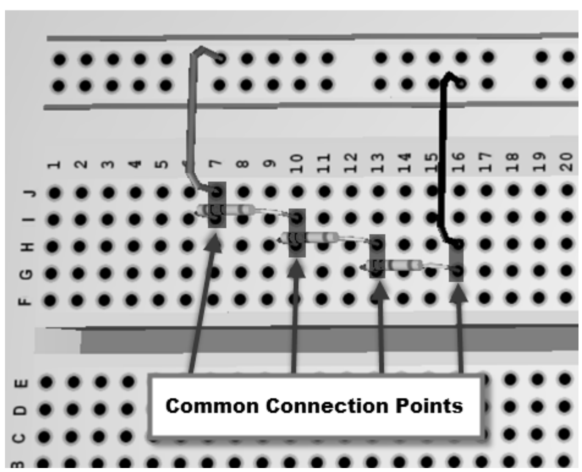
Activities & Assessments

1. A Simple Series Circuit
2. Series Aiding Voltages
3. Series Opposing Voltages
4. Critical Thinking

How to wire a breadboard in Series

Up to now, nearly all of the breadboard circuits created have been very simple series circuits. Now you are ready to begin using additional components. The theory is the same – there must be a continuous connection from positive through all components and then to ground.

In the image below, the flow of electrons can be followed from the red "power" bus (top line) to the blue "ground" bus (bottom line). Starting with the blue wire plugged into the red bus, notice how it connects to one end of the first resistor. The other end of that resistor shares a common connection with the next resistor, and that resistor shares a common connection with the third resistor. Finally, the black wire shares a connection with the third resistor and plugs in on the blue bus. A series circuit consists of wires and components that are connected in a continuous line from positive to ground.

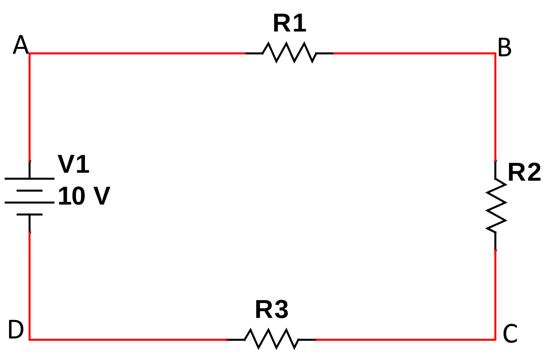


1: A Simple Series Circuit

Components & Equipment Needed

- Resistors, wire, and breadboard

Schematic



Specifications for Circuit

- VT = 10 V
- RT = 1.175 kΩ
- IT = 8.5 mA

Procedure

Step 1: Build the circuit shown in the schematic using the values below in both Multisim and on a breadboard. **For the total resistance, you may use only 3 standard (± 5%) value resistors of differing values.**

Step 2: Measure the voltage drops across each resistor and the current at each point (A, B, C, and D), and total current, then fill in the table below.

	Measurements		
	Multisim	**Breadboard**	**% Difference**
V_{R1} (R_1=_________)			
V_{R2} (R_2=_________)			
V_{R3} (R_3=_________)			
I_A			
I_B			
I_C			
I_D			
I_T			

Question

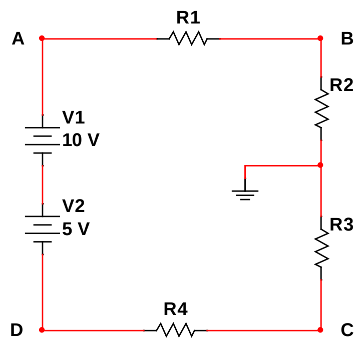
1. If the wire between R1 and R2 were to break, what would the voltage potential be between the two resistors? Explain your answer.

2: Series Aiding Voltage

Components & Equipment Needed

- Resistors, wire, and breadboard

Schematic



Specifications for Circuit

- Reuse the resistors from Part 1 above.
- R4 should bring the total resistance to 1.505 kΩ
- V1 = 10V; V2 = 5V

Procedure

Step 1: Build the circuit in **both** Multisim **and** on a breadboard as shown in the schematic above using specifications shown above.

Step 2: Take the measurements shown below and complete the table below:

	Measurements		
	Multisim	**Breadboard**	**% Difference**
V_{R1} (R_1=________)			
V_{R2} (R_2=________)			
V_{R3} (R_3=________)			
V_{R4} (R_4=________)			
V_T			
I_T			
A - GND			
B – GND			
C – GND			
D – GND			

Question

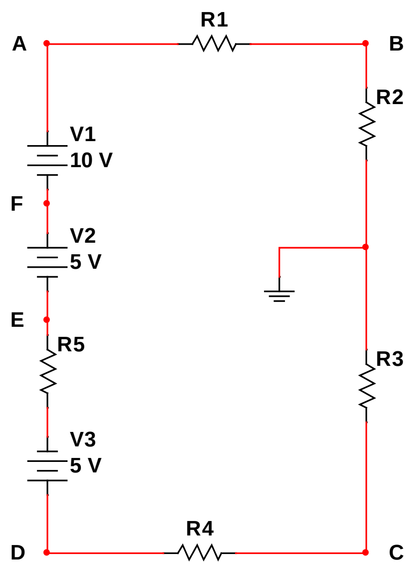
1. If the circuit opened at Point C, what would the voltage drop from D – GND be? Explain your answer.

3: Series Opposing Voltage

Components & Equipment Needed

- Resistors, wire, and breadboard

Schematic



Specifications for Circuit

- R1, R2, R3, and R4 the same as in Part 2
- R5 should bring the total resistance to 2.505 kΩ
- V1 = 10V; V2 = 5V; V3 = 5V

Procedure

Step 1: Build the circuit in both Multisim and on a breadboard as shown in the schematic above using the specifications shown above.

Step 2: Take the measurements shown below and complete the table:

	Measurements	
	Multisim	**Breadboard**
V_{R1} (R_1=_________)		
V_{R2} (R_2=_________)		
V_{R3} (R_3=_________)		
V_{R4} (R_4=_________)		
V_{R5} (R_5=_________)		
V_T		
I_T		
A - GND		
B – GND		
C – GND		
D – GND		
E – GND		

Questions

1. Calculate the voltage drop between point F and Ground.

2. Explain why some of the measurements are negative.

3. If R_5 were to open, calculate and explain the following:
    a. Voltage drop between B and C

    b. I_T

4: Critical Thinking

The Problem

Some time ago, your supervisor asked you to design a circuit. She wanted to use a light bulb that the company already used in other products, but because this was a specialized circuit, it was important that it dissipated a very specific amount of heat, or power. She didn't have much information on the lamp, except that it has 10 Ω of resistance. The amount of power that needs to be dissipated is a *total* of 45 W. The only kind of power supplies that the company uses are 12 V or 24 V. In addition, it is necessary that the voltage supply chosen be within ± 3% of the needed voltage.

After working through it, you discovered that your company would not be able to make this circuit to meet the customer's specifications. However, your supervisor has asked that you revisit this problem and consider how this circuit can be redesigned. Now that you know more about series circuits, you realize that it would be a simple thing to change the circuit. All the specifications stated above must be followed, with the exception of the addition of a single standard value resistor with a tolerance of± 5%, due to very limited space.

Some points to keep in mind:

- $R_{lamp} = 10\ \Omega$
- $P_{total} = 45$ W
- Power Supply = 12 V or 24 V
- Restrictions = required voltage and power supply voltage must be within 3% of each other.

Support your answers with logic and reasoning. Keep your explanations brief and concise.

1. Which power supply would be acceptable to use in this case?

2. Is the resistance value a standard value? If not, is there a standard value resistor that is adequate (tolerance of± 5%) for the specifications?