Parallel Circuits

Air Washington Electronics ~ Direct Current Lab

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Parallel Circuits

Overview

For this lab, the student is given two parallel circuits and is asked to calculate the resistor values using standard resistor values (±5%). The circuits must be built and analyzed in both Multisim and on a breadboard. For the first circuit a measurement indicating a circuit fault is given and the fault must be assessed and supported. For the second circuit, the student is asked to reduce the circuit to a simple equivalent series circuit using only standard resistor values. 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, plus 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, or pictorial layout.
- Demonstrate ability to predict circuit operation
- Demonstrate ability to test circuit operation
- Demonstrate ability to 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
- Reduce a set of components to an equivalent circuit using standard resistor values

Activities & Assessments

1. Simple Parallel Circuit
2. Solving a Parallel Circuit and Reducing to its Equivalent Circuit
3. Critical Thinking

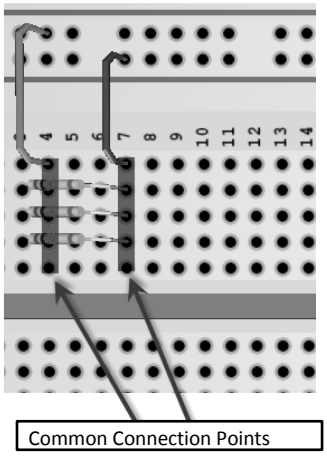
1: Simple Parallel Circuit

How to wire a breadboard in Parallel

Up to now, all of the breadboard circuits you have created have been simple series circuits. Parallel circuits on the breadboard are a bit more difficult and require attention to detail. The easiest way to start is to build the circuit to look as much like the schematic as possible. While this seems simplistic, there will be a point where it becomes intuitive.

In the parallel circuits we will be working with, the main thing to keep in mind is that all parallel branches share common connections with the both ends of the power supply. Translating what you see in the schematic to a breadboard is rather straight forward when you keep that in mind.

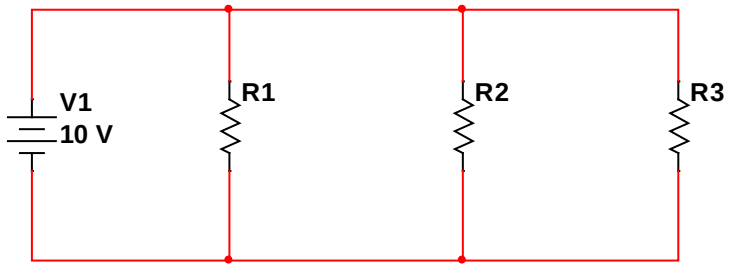
Shown in the image below is a simple parallel circuit with three resistors. The resistors all share a common connection point with both the "hot" (top bus) and the "ground" (bottom bus). It looks very much like the schematic for part one of this lab assignment.



Components & Equipment Needed

- Resistors, wire, and breadboard

Schematic



Specifications for Circuit

- V_T = 10 V
- R_1 = 4.3 kΩ
- R_{EQ} = 1 kΩ
- I_T = 10 mA

Procedure

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

Problem Solving Help

Before you panic, remember to review the information, or data, that you have for solving this problem. First, you know the total values that are required:

- V_T = 10 V
- R_1 = 4.3 Ω
- R_{EQ} = 1 kΩ
- I_T = 10 mA

The other pieces of information that you have are the formulas, laws, and theories that you have already learned.

- $V_{applied}$ is the same across parallel branches
- Ohm's Law: For each branch, $I = V_{applied}/R$
- Kirchhoff's Current Law: The total current, I_T, in the main line of a parallel circuit equals the sum of the currents in the individual branches
- Resistors in Parallel follow different rules than those in series.
  - R_{EQ} is less than any branch resistance
  - $R_{EQ} = \frac{1}{\frac{1}{R_1}+\frac{1}{R_2}+\cdots+\frac{1}{R_n}}$, reciprocal resistance formula when multiple parallel branches

Steps to Solving

1. A first step is to review the total, or equivalent, resistance required for the circuit, and any other relevant values.
2. Next, given that the total, or equivalent, resistance will be less than any single branch resistances, choose any reasonable number over 1 kΩ for the value of R_2.
3. Use a derivative of the reciprocal resistance formula to determine the value of R_3.

Step 2: Measure the voltage drops across each resistor and the total current, then fill in the table below.

	Multisim	Breadboard
V_{R1} (R_1 = 4.3 kΩ)		
V_{R2} (R_2 = _____)		
V_{R3} (R3 = _____)		
I_T		
I_1		
I_2		
I_3		
R_T		
R_1		
R_2		
R_3		

Question

1. Calculate the values of current and resistance given the fault shown in the chart. Explain how an open resistor affects total current and resistance.

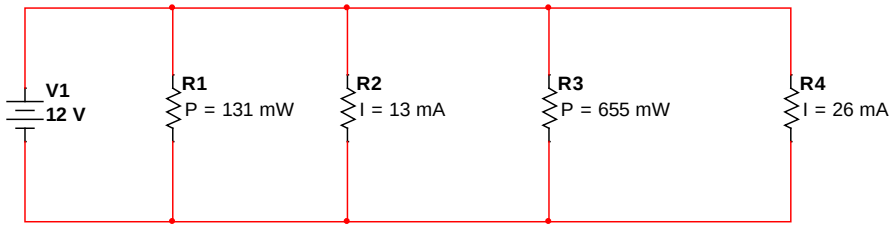
Fault	R_T	I_T
R1 Open		
R2 Open		
R3 Open		

2: Solving a Parallel Circuit and Reducing to its Equivalent Circuit

Components & Equipment Needed

- Resistors, wire, and breadboard

Schematic



Total Power = 1.25 W

Procedure

Step 1: Build the circuit in **both** Multisim **and** on a breadboard as shown in the schematic above using the specification shown in the schematic. Only standard value ±5% resistors will be used. HINT: If you get stuck, review the information that you have, including the values given and any formulas, laws, or theories you have learned.

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

	Multisim	Breadboard
V_{R1}		
V_{R2}		
V_{R3}		
V_{R4}		
V_T		
I_{R1}		
I_{R2}		
I_{R3}		
I_{R4}		
I_T		
R_1		
R_2		
R_3		
R_4		
R_T		
P_{R1}		
P_{R2}		
P_{R3}		
P_{R4}		
P_T		

3: Critical Thinking

Once again, your supervisor approaches you with a problem to solve. Another potential client has asked for a similar circuit as you had designed before. However, they want to be able to operate several different types of bulbs from the same circuit. Now that you have an understanding of parallel circuits, you know that you can solve this problem easily.

Because of industry standards, the total power dissipated must still be 45 W. The client wants three (3) bulbs and the choice of a 12 V or 24 V power supply. The three bulbs desired have resistances of 10Ω, 10Ω, and 15Ω. If all works well and everything in the circuit is within tolerance (± 5%), there won't be need for additional resistance. But if not, there is just enough room for a single standard (± 5%) value resistor.

Support all answers with calculations.

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

2. What is the equivalent resistance of the circuit? Is it within tolerances?