DC Circuits Laboratory — Project 1 (2 weeks)

Series-Parallel Circuits and Equivalent Resistance

Lab Objectives

When this lab exercise is completed, the student should be able to:

1. Solve DC circuits by analytical means
2. Work individually and as a team, use data analysis and plotting packages to plot data obtained by experimentation
3. Work individually and as a team to generate results and plots that demonstrate circuit analysis principles
4. Perform DC current and voltage measurements in simple and relatively complex DC circuits
5. Properly follow a schematic to construct basic DC circuits

Pre-Laboratory Preparation

Prior to your scheduled laboratory meeting time the following items need to be completed:

Research

1. Go to digikey.com and find, download and carefully review the data sheet for p/n 67-1105-ND (a 2 volt, red LED used in this experiment). Mark on the data sheet which lead is labeled ANODE.

On Line Learning

1. Review previous videos and materials on:
   i. Component ID
   ii. Protoboarding
   iii. Using the power supply and DMM

Preparation for the Prelab Quiz

1. Read this entire handout carefully and clarify anything you do not understand with your lab instructor BEFORE lab (*hint – read Lab Note 1*)
2. Calculate the nominal value for all of the circuit parameters to be measured or determined in the lab. This includes all voltages, currents, powers and equivalent resistance data for all three sections of this experiment (read the procedures).
3. Place all of your calculations from step 2 above into appropriate **Excel** data tables (7 of them, 3 of which you must create now) so that you can access them quickly for the online prelab quiz.
4. Leave room in your data tables for measured values and % error results.
5. You will have 10 minutes to complete the prelab quiz at the start of lab - **BE PREPARED.**

DC Circuits Lab Procedure:

PART 1 – Series Circuit

1. Build the circuit shown in Figure 1 on your breadboard using as few wires as possible and good construction techniques.
2. Using the bench top DMM:
   a. Measure the resistance of R_1 through R_4 and place these values in Table 1
   b. Measure the forward voltage drop of LED_1 and record this value in Table 1
3. Measure and record the following in Table 1:
   a. V_{ab}
   b. V_{bc}
   c. V_{cd}
   d. V_{de}
   e. V_{ef}
   f. V_{ae}
   g. I_1
4. Using the data obtained in Step 3, verify KVL for the circuit of Figure 1. Show your work just below Table 1.
5. Using the data obtained in Step 3, determine and record the following in Table 2:
   a. P_{V1} (the power supplied by the voltage source)
   b. P_{R1} (the power absorbed by R_1)
   c. P_{R2}
   d. P_{R3}
   e. P_{R4}
   f. P_{LED1}

6. Using the data recorded in Step 5, show that the power supplied by source V_1 equals the power absorbed by the circuit components in the circuit of Figure 1. Show your work just below Table 2.

7. Using your measured values for V_{ae} and I_1, determine the equivalent resistance of R1 through R4 in the circuit of Figure 1 and record this value and show your calculation just below Table 1.

Figure 1 - Series Circuit

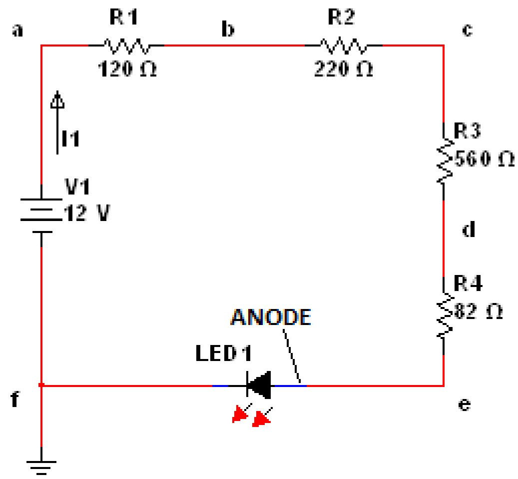

Table 1 - Resistor, Voltage and Current Measurements for Fig. 1 (use correct units)

Ref. Designator	R_1	R_2	R_3	R_4	LED_1 V_f		
Measured Value							
Circuit Parameter	V_{ab}	V_{bc}	V_{cd}	V_{de}	V_{ef}	V_{ae}	I_1
Measured Value							

KVL Verification for Figure 1 (general equation, then with the appropriate voltages):

R_{EQ} calculation (for R_1 through R_4) for Figure 1:

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Table 2 - Power Data for Figure 1 (use correct units)

Ref. Designator	V_1	R_1	R_2	R_3	R_4	LED_1
Power Dissipated (+) or Supplied (-)						

$P_{supplied} = P_{dissipated}$ verification for Figure 1:

8. Replace R_1 through R_4 in the circuit of Figure 1 with the equivalent (closest standard value) R_{EQ} resistor value available in lab (as shown in Figure 2). Use your calculated R_{EQ} value as a starting point. Try for less than a 5% error.

9. Complete Table 3 by taking the appropriate data using the bench-top DMM and calculating the necessary power parameters.

Figure 2- Reduced Series Circuit

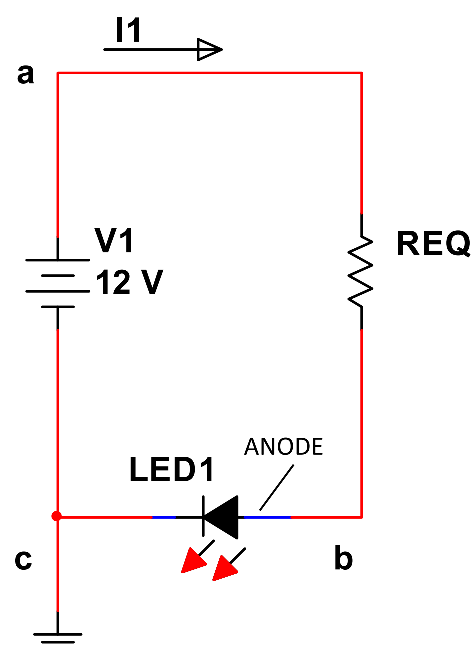

Table 3- Data for Figure 2

Ref. Des.	V_1	R_{EQ}	$LED_1\ V_f$
Measured Value.			
Parameter	V_{ab}	V_{bc}	I_1
Measured Value.			
Parameter	P_{V1}	P_{REQ}	P_{LED1}
Power Absorbed (+) or Supplied (-)			

Calculations for Table 3:

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Part II – Series/Parallel Circuit

*** NOTE: For PART II prelab you will create three data tables using Microsoft Excel (described in the steps below). Place these tables and the pertinent calculations on one side of a single sheet of paper. Make sure your work is neat and legible and that your tables are properly titled and contain headers and units.**

1. Obtain the components to build the circuit shown in Figure 3 and using the bench top DMM:
   a. Measure the resistance of R_1 through R_4 and place these values in your own data table - Table 4.
2. Build the circuit shown in Figure 3 on your breadboard using as few wires as possible and good construction techniques.
3. Measure and record the following in Table 4:
   a. V_{ab}
   b. V_{bc} (V_F)
   c. I_{R1}
   d. I_{R2}
   e. I_{R3}
   f. I_{R4}
   g. I_1
   h. I_2
4. Using the data obtained in Step 3, verify KCL for the circuit of Figure 3. Show your work just below Table 4.
5. Using the data obtained in Step 3, determine and record the following in (your own data table) Table 5:
   a. P_{V1} (the power supplied by the voltage source)
   b. P_{R1} (the power absorbed by R_1)
   c. P_{R2}
   d. P_{R3}
   e. P_{R4}
   f. P_{LED1}
6. Using the data recorded in Step 5, show that the power supplied by source V_1 equals the power absorbed by the circuit components in the circuit of Figure 3. Show your work just below Table 5.
7. Using your measured values for V_{ab} and I_1, determine the equivalent resistance of R_1 through R_4 in the circuit of Figure 3 and record this value and show your calculation just below Table 4.
8. Replace R_1 through R_4 in the circuit of Figure 3 with the one closest standard resistor value available in lab as shown in Figure 4.
   a. Use your calculated R_{EQ} value as a starting point
9. Create and complete Table 6 (similar to Table 3) to hold your data and results for voltage, current and power for the reduced circuit of Figure 4.
   a. Take the appropriate data using the bench top DMM and by calculating and recording the necessary parameters.

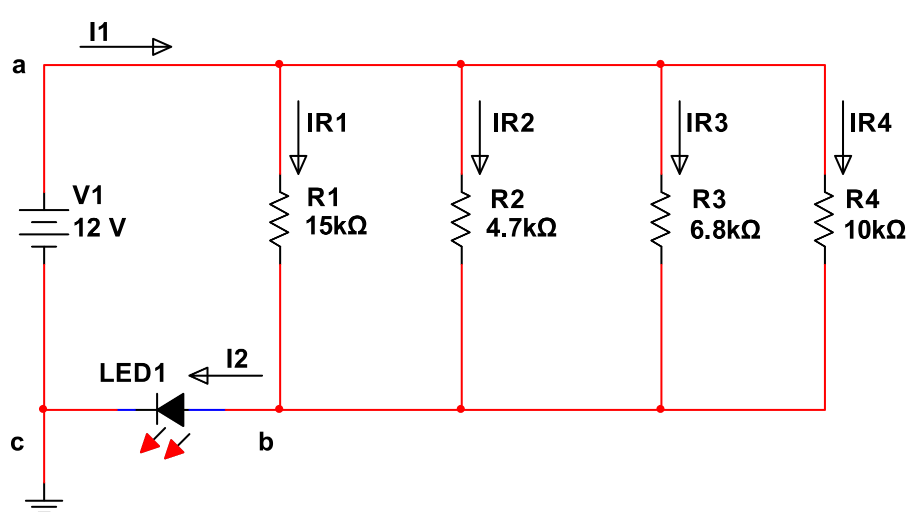

Figure 3 - Series/Parallel Circuit

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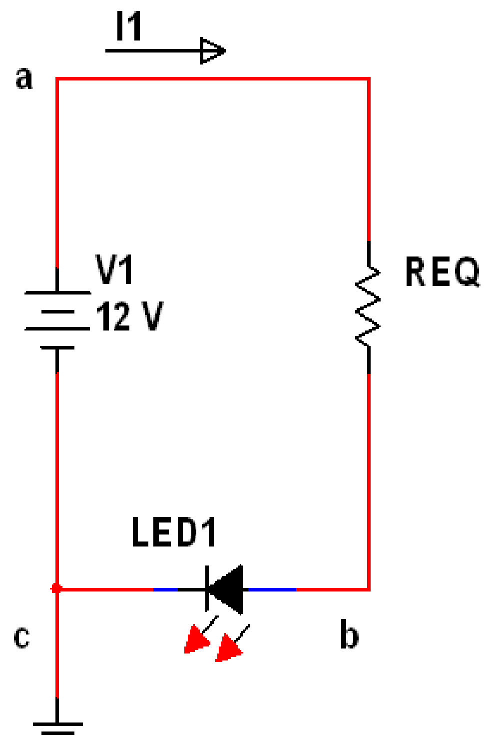
Part III - I/V Characteristic

1. Using the circuit shown in Figure 4 with the value of R_{EQ} you used in Part II, step 8, vary V_1 from 0 to 15V in 1V increments
   a. Record I_1 and V_{bc} in Table 7

Table 7 – I_1 and V_{bc} for Fig.4 as V_1 is Varied from 0V to 15V

V_1 (V)	I_1 (mA)	V_{bc} (V)
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

Figure 4. Reduced Series/Parallel Circuit



   b. **Using Microsoft Excel** and on a separate page for submission, create a professional looking graph showing the circuit current, I_1, as a function of the applied voltage, V_1, over the range given in Table 7. Add a "trendline" to your plot from within Excel and using the I-V slope, calculate the equivalent circuit resistance seen by the source.
   c. Include your Microsoft Excel data table with this plot.

Post Lab Requirements:

After lab, **<u>during a time specified by your instructor</u>**, take the post lab quiz. You may use the prelab work, the lab data and answers to the lab questions as reference material for this quiz.

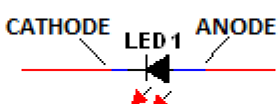
Submit your completed documentation at the beginning of next week's lab <u>before</u> you take that week's prelab quiz. **Your team submission package** will be graded and returned with comments. Submit the following, stapled together:

<u>Submit the following four pages</u>, in this order (and nothing else):

- **Page 1** - Your team cover sheet with all 3 instructor signatures, filled-in by EACH team member
- **Page 2** – (<u>include the schematic from Figure 1):</u>
  Assuming nominal resistor values, compare in an Excel table your prelab calculations with your laboratory data for the information contained in Table 1.
  a. Calculate the % error for each parameter and show one sample calculation below your table
  b. Explain any significant discrepancies below your table (use WORD and complete sentences)
- **Page 3** – Your schematic, data table, Excel plot (with trend line) and Rckt calculation/interpretation and value from PTIII
- **Page 4** – (<u>Restate and answer each question below using full sentences, proper grammar and WORD. Show your calculations as well!)</u>
  Using the data and plot from Part III (see page 3), answer the following:
  a. What is the equivalent resistance seen by the source, V_1 in the circuit shown in Figure 4 (use the slope of the <u>linear portion</u> of your trendline)?
  b. What is the apparent resistance of LED_1 when V_1 is 12V? (Use Ohm's law at this point R=V/I)
  c. What is the apparent resistance of LED_1 when V_1 is 3V? (Use Ohm's law at this point R=V/I)
  d. What is the power dissipated by LED_1 when V_1 = 3V? When V_1 = 12V? (P=IV for <u>any</u> device)

Lab Note 1: LEDS

An LED is also known as a Light Emitting Diode. It's a semiconductor device with the property that it only allows current to flow in one direction and blocks current trying to flow in the opposite direction (diode). When the current is flowing, photons (light) are emitted. The LED we're using is a red LED. The amount of light emitted is proportional to the amount of current that flows through it. This kind of LED typically has about 20mA of current flow in order to make the diode glow brightly. Remember that the diode will only allow current to flow in one direction. The current must enter the ANODE and leave the CATHODE. Here's the symbol:



If you put a diode into the circuit backwards, no current will flow, and the diode will be dark. This is why it's important to correctly identify the ANODE of a diode. On the circuit diagram of figure 1, the ANODE is marked. On the Data Sheet, the ANODE is identified in a drawing of the actual diode.

Note also that the current flows in the direction of the diode arrow. When you build the circuit, be sure to insert the LED in the correct direction. If you build the circuit and the diode is dark, it's probably in backwards. When an LED is "ON" (that is when current is flowing through it) the voltage across it is steady, and does not change much if the current changes. This is a NON-LINEAR device; it does not obey OHM's law in the same manner that a resistor does. The voltage across an "ON" diode is called the Forward Voltage, and is usually called out as V_F. In the Data Sheet V_F is given as 2V typical (that means it's about 2 volts over a range of different currents). When you calculate the currents in the circuits during your prelab, assume that 2V appears across the diode whenever the circuit is powered on. The rest of the voltage (10V) appears across the resistors in the circuit. That's KVL at work.

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Team Name and Lab Section: ....

Team Members Present (printed)

First Name, Last Name	Roles This Lab (week 1,week 2)	RIT Program

TEAM LABORATORY GRADE

(all work done neatly, legible, complete and organized including data, data tables and questions, completed on time, all signoffs in place, no missing or extraneous information)

PTI Signature _______ **PTII Signature _______** **PTIII Signature ______**

Laboratory Results (all work neat and complete, organized, signoffs on-time and in place) **__/30**

Submission Docs (See page 6 of this handout - pages 2, 3 and 4 including schematics, data tables, questions, properly generated, formatted and completed per instructions) **__/30**

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Final Team Grade .... **/60**

Instructor comments: