Name: ____________________________

ECET 231 – Circuit Analysis I

Lab 4
Series Circuits with Light Emitting Diodes

Objective: Students successfully completing this lab will accomplish the following objectives:
1. Gain understanding of the behavior of Light Emitting Diodes (LEDs)
2. Learn to analyze and verify by measurements the characteristics of series LED-resistor circuits.
3. Gain understanding of open and short circuits.

Lab Report: A combined formal lab report will be required for lab exercises 2, 3 and 4. Reports will be due one week after lab 4 has been performed. All lab handouts complete with tabulated data and calculations should be added as attachments to your formal report.

Equipment: Resistor, LEDs (2), Digital Multimeter (DMM), connecting leads, alligator clips, breadboard and jumper wires.

Procedure:

1. Light Emitting Diodes (LEDs) operate with voltages between 1 V and 3 V. Currents in the diode typically fall in the range of 5-100 mA depending on the desired brightness of the emitted light and the amount of semiconductor material in the LED. A circuit which can be used to light an LED is shown in Figure 1.

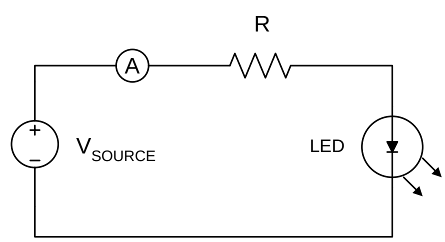

Figure 1: Series Circuit with Light Emitting Diode

Assuming a voltage drop across the LED of 2 V and a supply voltage of 12 V, calculate the resistance, R, required to generate a current of 20 mA. Also, calculate the resistor voltage and power, LED power and source power. Show your calculations below and record your results in Table 1.

Table 1: Calculated electrical quantities in a series LED-resistor circuit

Component	Voltage (V)	Current (mA)	Resistance (Ω)	Power (mW)
Source	12		n/a	
Resistor		20		
LED	2			

2. Select a resistor from the lab storage room which most closely meets the value calculated in step 1. Determine the power rating that the resistor must have to meet the calculated resistor power.

Selected resistor = ____________ Power rating = ____________

3. Measure and record the resistance of the resistor. Connect the series LED-resistor circuit shown in Figure 1. Set the power supply to 12 V. The LED should be lit. Measure and record the resistor and LED voltages as well as the circuit current.

$R =$ ____________ $I =$ ____________

$V_R =$ ____________ $V_{LED} =$ ____________

4. From these measurements, compute the applied power, the resistor power and the LED power. Show your calculations below. Present all of the results for the series LED-resistor circuit in Table 2.

$P_T =$ ____________

$P_R =$ ____________

$P_{LED} =$ ____________

Table 2: Summary of results for the series LED-resistor circuit

Quantity	**Device**	**Calculated Value**	**Measured (or computed from measured) value**
Resistance	Resistor		
Voltage	Source	12 V	
	Resistor		
	LED		
Current	Source		
	Resistor		
	LED		
Power	Source		
	Resistor		

5. Add a 10 kΩ potentiometer in series with the resistor. Connect to the center tap and to one of the end terminals of the potentiometer. Set the power supply to 12 V. Adjust the potentiometer to where the LED is dimmest. Measure and record the LED voltage and the circuit current. Calculate the LED power.

$I =$ ____________

$V_{LED} =$ ____________

$P_{LED} =$ ____________

Disconnect the potentiometer and measure the resistance from the center tap to the winding end used in the circuit.

$R_{Pot} =$ ____________

6. Reconnect the circuit in Figure 1 and add a second LED in series with the first LED. Set the power supply to 12 V. Both LEDs should be lit. If they are not, check the polarity of the LEDs. When both are lit, measure the current and all device voltages.

   V_{SOURCE} = 12 V

   I = ____________ V_R = ____________

   V_{LED1} = ____________ V_{LED2} = ____________

   Add all device voltages. Sum of voltages = ____________

   Does the sum of device voltages add up to the source voltage? ____________

7. Using a screw driver or other implement, short out one of the LEDs. What happens to the other LED? Select one answer from the choices below.

   ____ Gets brighter ____ Gets dimmer

   ____ Remains the same ____ Gets very bright then burns out

   ____ Other (explain) ____

8. Connect a jumper wire to short out one of the LEDs. The other LED should be lit. Measure the current and all device voltages.

   V_{SOURCE} = 12 V

   I = ____________ V_R = ____________

   V_{LED1} = ____________ V_{LED2} = ____________

   Add all device voltages. Sum of voltages = ____________

   Does the sum of device voltages add up to the source voltage? ____________

   Based on these results, what can you conclude about the voltage drop across a device that has been shorted out? Give your response in your formal report.

9. Remove the jumper wire used to create the short circuit. Now, create an open circuit by removing the LED which had been shorted out. Set the power supply to 12 V. Measure the current and all devices voltages.

   V_{SOURCE} = 12 V

   I = ____________

   V_R = ____________

   V_{LED1} = ____________

   V_{LED2} = ____________

   $V_{OpenCircuit}$ = ____________

   Add all device voltages. Sum of voltages = ____________

   Does the sum of device voltages add up to the source voltage? ____________ If not, why do you think this might be so. Give your response in your report.

Based on these results, answer the following questions in your formal report.

- Suppose you have a single power supply and several devices in series. One of the devices burns out and becomes open-circuited. The voltage of the open-circuited device takes on the voltage of what other part of the circuit?

- In this same scenario, the voltage drops across the remaining devices which are not shorted out take on what value?

Present the results from steps 6, 8 and 9 for shorted and open-circuited LEDs in the Table below.

Table 3: Results due to shorting out or open-circuiting a device in a series circuit

Quantity	**Device**	**Normal**	**With 1 LED Shorted Out**	**With 1 LED Open-Circuited**
Current	Any			
Voltage	Source	12 V	12 V	12 V
	Resistor			
	LED 1			
	LED 2			

For the Relevant Theory / Background Information Section of your report:

Address the questions mentioned previously in this lab and provide explanations to your responses. Give basic information such as:

- What is an LED?
- How is it connected to a circuit?
- Are there advantages for the LED over other forms of lighting?
- How can one control the intensity of an LED?

For the Experimental Data / Analysis section of your report:

Draw conclusions from this lab concerning the behavior of series circuits. For example: based on your observations, increasing the resistance in the LED circuit has what effect on:

- Brightness of the LED?
- Circuit current
- LED power

Also:

- Why does current increase in a series circuit when one of the devices is short circuited?
- Why does the voltage of an open-circuited device take on the voltage of (*answer to question in step 9*) in a series circuit?
- Why do the voltages of the other devices in an open-circuited series circuit take on a value of (*answer to question in step 9*)?