EE 97 Fall 2014

Lab#2: Graph Current vs. Voltage of a Two-Terminal Component

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Station 3

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**Preface**

All experiments were successfully conducted in Engineering Building room 249, on September eleventh, 2014.

**Experiment 1**

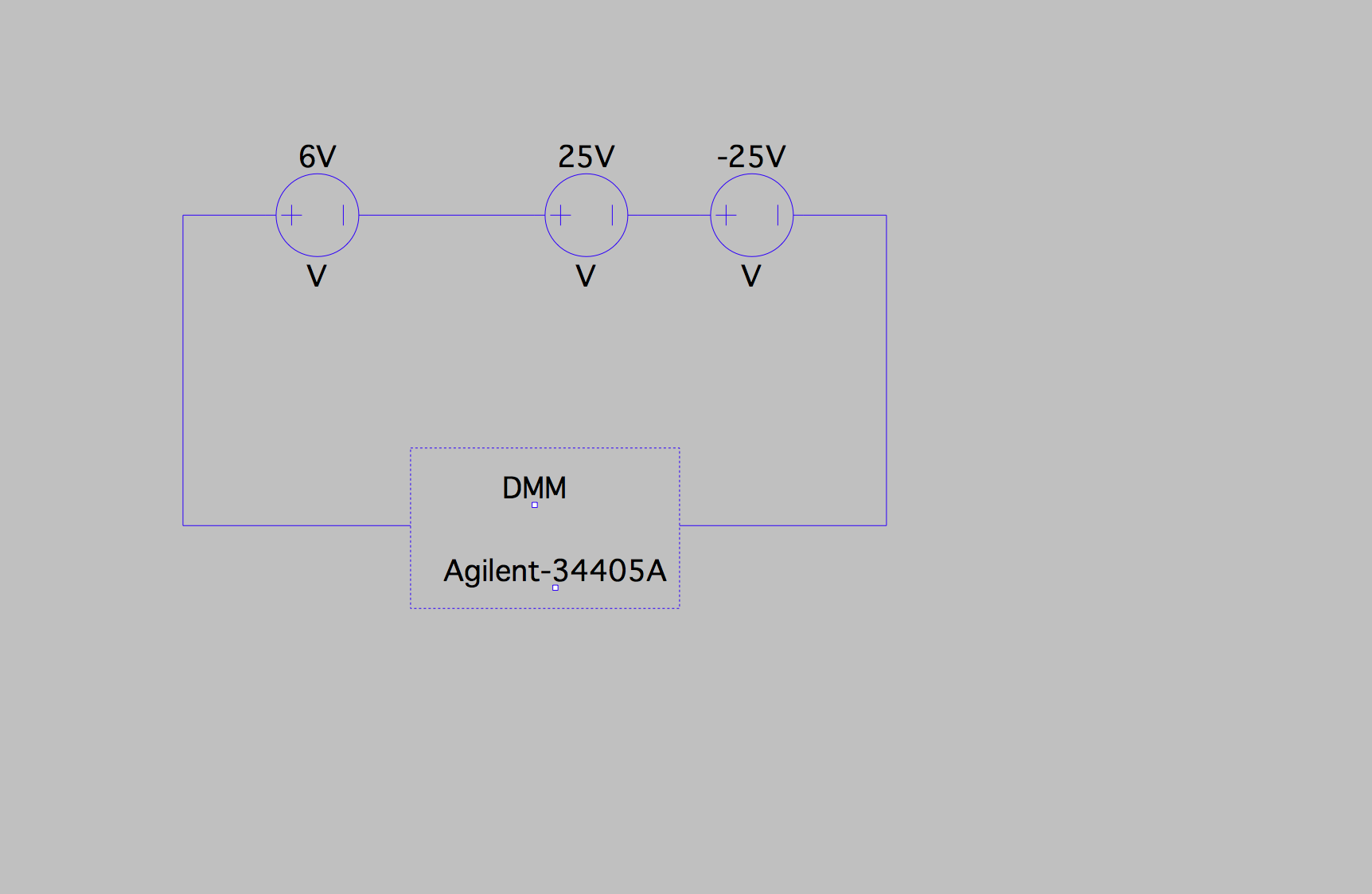
****Experiment one familiarized the use of the DC power supply (HP E3631A). The power supply has three terminals that provide a variety of voltages. The objective was to successfully read 30V, 55V, and two sets of simultaneous voltages.

Figure 1: Experiment 1 circuit diagram

The set up shown in figure 1 is able to measure voltages of the range -25V to 56V. By connecting the 25V voltage source in series with the 6V voltage source a voltage of 30V is achievable. By adding the third 25V in series with the other two voltage sources, 55V can be achieved. Using the same set up as before +6, -6 and -2V can be simultaneously seen on the DMM. In addition voltages +12, +5 and -5V can be measured with the same set up.

**Experiment 2**

Purpose of this experiment is to understand the change in voltage and current between two resistors. The power supply is set at 2V with a current limit at 0.1A. The two resistors observed are 10Ω and 47Ω.

Table 1: Data for two resistors

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Load Resistance [Ω] | Voltage/[V] | Current I/ [A] | CC/CV | V/I [Ω] |
| Open Circuit | 2V | .001A | CV | 2000 Ω |
| 10 Ω | .953V | .097A | CC | 9.82 Ω |
| 47 Ω | 2V | .045A | CV | 44.44 Ω |

**Experiment 3**

Testing the power rating of a resistor yields many different attributes as to how much current can flow and how much power can the resistor dissipate. By calculating the power dissipating of a resistor and then conducting an experiment that applies voltage two different types of resistors the calculated and measured values can be compared.

Power Dissipation of a 10Ω resistor with 5V:

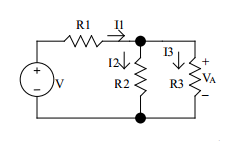
= = 2.5 W

Applying 1.58V to a 1/4W 10 Ω resistor mildly increases the resistors temperature.

Applying 5V to a 1/4W 10 Ω resistor increases the resistors temperature to point it starts to smoke and turn black. The current reading was .51A and voltage reading was 5V.

Applying 5V to a 5W 10 Ω resistor increases the resistors temperature gets hot very quickly. The current reading was .408A and voltage reading was 5V. A 5W was supplied and used instead of a 10W as stated in the lab manual.

**Experiment 4**

By constructing questions 3 and 4 from Pre Lab 2, the voltages and current across all resistors was measure and compared to the calculated values. An indirect method was used to measure the resistance and voltage then by using Ohm’s law the current was calculated.

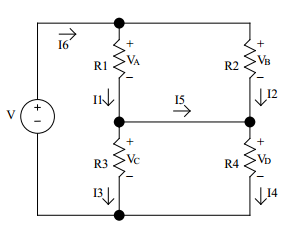


Figure 2: Pre Lab question 3

V=10V

R1=1KΩ

R2=2KΩ

R3=5.1KΩ Figure 3: Pre Lab question 4

V=12V

R1=2KΩ

R2=2.7KΩ

R3=1KΩ

R4=5.1KΩ

Table 2: Data for Figure 3

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Label** | **Resistance[KΩ]** | **Voltage V/[V]** | **Measured Current I/[A]** | **Calculated Current I/[A]** |
| R1 | 0.95 | 4.16 | 4.38E-03 | 4.10E-03 |
| R2 | 1.9 | 2.34 | 1.23E-03 | 2.94E-03 |
| R3 | 5 | 2.34 | 4.68E-04 | 1.15E-03 |

Table 3: Data for Figure 3

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Label** | **Resistance[KΩ]** | **Voltage V/[V]** | **Measured Current I/[A]** | **Calculated Current I/[A]** |
| R1 | 1.9 | 6.9 | 3.63E-03 | 3.52E-03 |
| R2 | 2.63 | 6.9 | 2.62E-03 | 2.61E-03 |
| R3 | 0.95 | 5.09 | 5.36E-03 | 5.53E-03 |
| R4 | 5 | 5.09 | 1.02E-03 | 2.62E-03 |

Figure 2 and 3 shows circuits used to calculate currents across resistors using circuit analysis methods, then these schematics were constructed upon a breadboard where the values were measured and compared to the calculated. From table 2 and 3 it can be seen that the calculated and measured are not the same.

**Experiment 5**

A 14V CL incandescent lamp (part number: 756 Lamp) was used in experiment five to find the resistance and power of the light bulb from a voltage range of 0V to 12V.

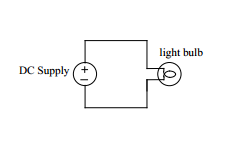


Figure 4: Experiment 5 Circuit Schematic

Sample Calculations

= = 9.09Ω

P== 0.6\*0.032=0.02W

Table 4: Data for light blub

|  |  |  |  |
| --- | --- | --- | --- |
| Voltage V/[V] | Current I/[A] | Resistance (V/I)/[Ω] | Power (V\*I)/[W] |
| 0 | 0.001 | 0 | 0 |
| 0.2 | 0.022 | 9.09 | 0.00 |
| 0.6 | 0.032 | 18.75 | 0.02 |
| 0.8 | 0.042 | 19.05 | 0.03 |
| 1 | 0.046 | 21.74 | 0.05 |
| 2 | 0.066 | 30.30 | 0.13 |
| 3 | 0.083 | 36.14 | 0.25 |
| 4 | 0.098 | 40.82 | 0.39 |
| 5 | 0.112 | 44.64 | 0.56 |
| 6 | 0.124 | 48.39 | 0.74 |
| 7 | 0.136 | 51.47 | 0.95 |
| 8 | 0.147 | 54.42 | 1.18 |
| 9 | 0.157 | 57.32 | 1.41 |
| 10 | 0.168 | 59.52 | 1.68 |
| 11 | 0.177 | 62.15 | 1.95 |
| 12 | 0.187 | 64.17 | 2.24 |

Graphing the data form table 4 the curve has a rise over run of . This means that the resistance is proportional to the voltage.

Graph 1: Resistance vs Voltage

Graph 2: Current vs Voltage

Graphs one and two show that lower voltage means the bulb will have less resistance. This is due to the properties of the filament used in light bulbs to be able to control the amount of light through voltage.

**Experiment 6**

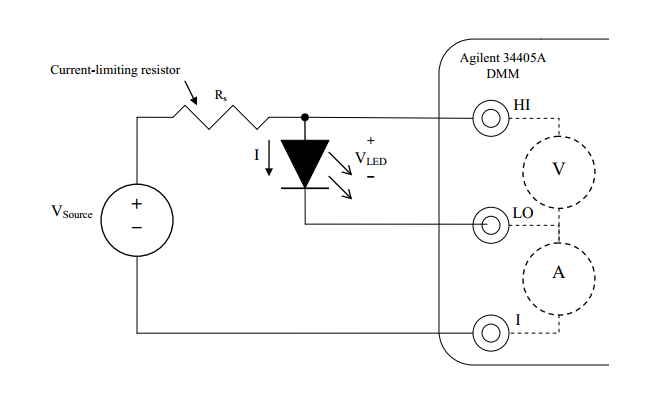
Provided with a Red Diffused LED (part number: LEDRDT1-3/4) and a Green Diffused LED (part number: LEDGDT1-3/4), for experiment six voltage was passed through each LED in diode’s forward direction and diode’s reverse direction. While evaluating the amount of light emitted from the LED also the currents and voltages were recorded as the voltage was swept from 0V to 10V. Also a 470Ω resistor was used as a current-limiting resistor to prevent damage to the LED.

Figure 5: Experiment 6 Schematic

Table 5: Green and Red LED Data

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| RED LED |  |  |  |  |
| Power Supply HPE3631A | | DMM Agilent 34405A | |  |
| Source Voltage V/[V] | Source Current I/[A] | Diode Voltage V/[V] | Diode Current I/[mA] | LED Brightness |
| 0 | 0 | 0.004 | 0 | No Light |
| 0.5 | 0 | 0.49 | 0 | No Light |
| 1 | 0 | 0.99 | 0.001 | No Light |
| 1.5 | 0 | 1.48 | -0.0131 | No Light |
| 2 | 0 | 1.65 | -0.717 | No Light |
| 2.5 | 0.001 | 1.69 | -1.66 | Barley Visible |
| 3 | 0.002 | 1.72 | -2.65 | Barley Visible |
| 4 | 0.004 | 1.77 | -4.65 | Barley Visible |
| 5 | 0.006 | 1.8 | -6.68 | More Noticeable |
| 6 | 0.008 | 1.83 | -8.72 | Very Bright |
| 7 | 0.01 | 1.85 | -10.78 | Very Bright |
| 8 | 0.12 | 1.8 | -13.09 | Very Bright |
| 9 | 0.014 | 1.9 | -15.09 | Very Bright |
| 10 | 0.16 | 1.92 | -15.09 | Very Bright |
|  |  |  |  |  |
| Green LED |  |  |  |  |
| Power Supply HPE3631A | | DMM Agilent 34405A | |  |
| Source Voltage V/[V] | Source Current I/[A] | Diode Voltage V/[V] | Diode Current I/[mA] | LED Brightness |
| 0 | 0 | -0.003 | 0 | No Light |
| 0.5 | 0 | 0.49 | 0 | No Light |
| 1 | 0 | 0.99 | -0.001 | No Light |
| 1.5 | 0 | 1.49 | -0.002 | No Light |
| 2 | 0 | 1.82 | -0.036 | No Light |
| 2.5 | 0 | 1.88 | -1.28 | Barley Visible |
| 3 | 0.001 | 1.91 | -2.26 | Barley Visible |
| 4 | 0.003 | 1.95 | -4.26 | Barley Visible |
| 5 | 0.005 | 1.99 | -6.28 | Bright |
| 6 | 0.007 | 2.02 | -8.31 | Bright |
| 7 | 0.009 | 2.05 | -10.36 | Very Bright |
| 8 | 0.012 | 2.08 | -12.64 | Very Bright |
| 9 | 0.014 | 2.1 | -14.74 | Very Bright |
| 10 | 0.016 | 2.13 | -16.83 | Very Bright |
|  |  |  |  |  |
| Reverse RED LED |  |  |  |  |
| Power Supply HPE3631A | | DMM Agilent 34405A | |  |
| Source Voltage V/[V] | Source Current I/[A] | Diode Voltage V/[V] | Diode Current I/[mA] | LED Brightness |
| 0 | 0 | -0.003 | 0 | No Light |
| 0.5 | 0 | 0.49 | 0 | No Light |
| 1 | 0 | 0.99 | 0 | No Light |
| 1.5 | 0 | 1.49 | -0.001 | No Light |
| 2 | 0 | 1.99 | -0.002 | No Light |
| 2.5 | 0 | 2.49 | -0.003 | No Light |
| 3 | 0 | 2.99 | -0.003 | No Light |
| 4 | 0 | 3.99 | -0.004 | No Light |
| 5 | 0 | 4.99 | -0.005 | No Light |
| 6 | 0 | 5.99 | -0.006 | No Light |
| 7 | 0 | 6.99 | -0.007 | No Light |
| 8 | 0 | 7.99 | -0.008 | No Light |
| 9 | 0 | 8.99 | -0.009 | No Light |
| 10 | 0 | 9.99 | -0.01 | No Light |
|  |  |  |  |  |
| Reverse Green LED |  |  |  |  |
| Power Supply HPE3631A | | DMM Agilent 34405A | |  |
| Source Voltage V/[V] | Source Current I/[A] | Diode Voltage V/[V] | Diode Current I/[mA] | LED Brightness |
| 0 | 0 | -0.003 | 0 | No Light |
| 0.5 | 0 | 0.49 | 0 | No Light |
| 1 | 0 | 0.99 | 0 | No Light |
| 1.5 | 0 | 1.49 | -0.001 | No Light |
| 2 | 0 | 1.99 | -0.002 | No Light |
| 2.5 | 0 | 2.49 | -0.003 | No Light |
| 3 | 0 | 2.99 | -0.003 | No Light |
| 4 | 0 | 3.99 | -0.004 | No Light |
| 5 | 0 | 4.99 | -0.005 | No Light |
| 6 | 0 | 5.99 | -0.006 | No Light |
| 7 | 0 | 6.99 | -0.007 | No Light |
| 8 | 0 | 7.99 | -0.008 | No Light |
| 9 | 0 | 8.99 | -0.009 | No Light |
| 10 | 0 | 9.99 | -0.01 | No Light |

Table five provides a vast amount of data related to how voltage and current responds to a LED. Current can only pass through the LED in its positive direction also known as forward bias. This eludes to the fact more voltage increased brightness. However if current is passed through the reverse direction known as reverse bias the readings for current is zero, as it does not allow current to pass which means there is not light emitted. After a certain point the LED will let current pass in the reverse direction rendering the component useless.

Graph 3: Red LED Graph

Graph 4: Green LED Graph

Graphs three and four produce a variable graph from the negative range to the positive range of the LED’s forward and reverse bias. In graph three some data seems to be inconsistent as the forward bias plot should be under 3A and be as close to a straight line as possible.

**Experiment 7**

After a thorough analysis of voltage and current through a LED and light bulb, lastly a zener diode (part number: 1N5434B) was analyzed. Connecting a current limiting resistor between the diode and the power supply to prevent damage. Experiment seven is fundamentally same as experiment six but with a different component.

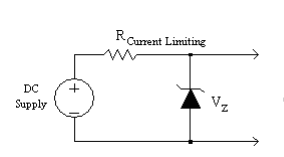


Figure 6: Experiment 7 Schematic

Table 6: Zener LED Data

REVERSE BIAS

|  |  |  |  |
| --- | --- | --- | --- |
| Power Supply HPE3631A |  | DMM Agilent 34405A |  |
| Source Voltage V/[V] | Source Current I/[A] | Diode Voltage V/[V] | Diode Current I/[mA] |
| 0 | 0 | -0.003 | 0 |
| 0.5 | 0 | 0.49 | 0 |
| 1 | 0 | 0.99 | -0.001 |
| 1.5 | 0 | 1.49 | -0.001 |
| 2 | 0 | 1.99 | -0.002 |
| 2.5 | 0 | 2.49 | -0.002 |
| 3 | 0 | 2.99 | -0.003 |
| 4 | 0 | 3.99 | -0.004 |
| 5 | 0 | 4.99 | -0.0018 |
| 6 | 0 | 5.95 | -0.83 |
| 7 | 0.001 | 6.06 | -1.95 |
| 8 | 0.003 | 6.07 | -4.022 |
| 9 | 0.005 | 6.08 | -6.09 |
| 10 | 0.007 | 6.09 | -8.16 |
|  |  |  |  |
| FORWARD BIAS |  |  |  |
| Power Supply HPE3631A |  | DMM Agilent 34405A |  |
| Source Voltage V/[V] | Source Current I/[A] | Diode Voltage V/[V] | Diode Current I/[mA] |
| 0 | 0 | 0 | 0 |
| 0.5 | 0 | 0.49 | 0.56 |
| 1 | 0 | 0.72 | 1.5 |
| 1.5 | 0.001 | 0.75 | 2.55 |
| 2 | 0.002 | 0.77 | 3.58 |
| 2.5 | 0.003 | 0.78 | 4.61 |
| 3 | 0.004 | 0.792 | 6.68 |
| 4 | 0.006 | 0.804 | 8.7 |
| 5 | 0.008 | 0.813 | 11.06 |
| 6 | 0.01 | 0.82 | 11.06 |
| 7 | 0.012 | 0.82 | 13.2 |
| 8 | 0.014 | 0.83 | 15.34 |
| 9 | 0.016 | 0.837 | 17.5 |
| 10 | 0.019 | 0.839 | 19.66 |

A zener diode passes current and voltage in the reverse direction. As seen from the data the data in the reverse bias the diode allows voltage to pass but in the forward direction it limits it to a certain threshold. A graph is attached to show the zener diode forward bias voltage vs the current.

**Conclusion**

Experiment one and two and three are very simple and enhance knowledge on the usage and understanding of lab equipment and resistors. These first three experiments are based on the previous lab to future analyze resistors. Comparing the values of the measured and calculated current for experiment four some measured values come within range of the calculated currents. For the currents related to figure four the measured values were significantly off this can be due to incorrect calculation of the calculated currents. There are multiple ways to measure I5 and I6 for figure four some include nodal analysis, mesh analysis or voltage and current division. These methods use Kirchhoff’s Circuit Law and Kirchhoff’s Voltage Law. Graphing is very important many data sheets for components come with many different types of graphs, which help analyze the functionality of many different components. For experiment five a graph was plotted to show current vs voltage (graph 2) and resistance vs voltage (graph 1). Future analysis of current vs voltage in experiment six. Instead of using a bulb, which has no confliction with polarity, a LED was used which can only pass voltage and current in one direction. Hence seen in table five when the LED was reversed there was no light and no current. For the forward bias there was a consistent relation between the source current and the current measured by the DMM. Lastly a component was introduced called a zener diode. This diode serves the same functionality as a LED however this diode functions in reverse bias. From table six it can be seen the diode voltage gets to 6V and does increase. This hints to the diode being a 6V zener diode as it has a reverse bias threshold of 6V. The striped line side on the zener diode is the cathode while the other side is the anode. In conclusion this lab enhanced the usage of many different and new lab equipment. Also new components were analyzed and graphed to see how they function and how they are used in real world circuit usage and analysis.

Note: Figures 2, 3,4,5,6 were taken from EE 97 Lab Manual by P. Hsu