Physics 117 Lab 1: Introduction to Electronics

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1. Beginning Exercises

To better analyze the physical world we need to use electronics as they can gather and manipulate information for us. In this laboratory we begin our analysis of electronics and electricity in a methodical approach, by first creating and analyzing basic circuits with a direct current (DC) power supply and analyzing the circuits with digital voltmeter (DVM) which was a multimeter in reality as well as a large tabletop multimeter and an Oscilloscope. For variation of sources we also used a alternating current (AC) power supply and a wave function generator.

To prep for the lab we first began with a series of questions.

1.1. Part A

The first exercise we accomplished was setting the DC voltage to 5 Volts on the DC power supply we then used banana cables to connect it to the lab top multimeter which read a result of 5.045 Volts and then using the DVM we got a measurement of 5.05 Volts, lastly with the Oscilloscope we received a measurement of 5.06 Volts. The purpose of doing this was to show the dial on the voltage source is not wholly accurate and has some spread afterwards. The measurement of the oscilloscope is shown in figure 1.

1.2. Part B

The next step before progressing required a Teaching Assistant to evaluate our knowledge of Ammeters and Ohmmeter. First we explained why a ammeter cannot be connected to a voltage source directly. The reason why you cannot do this because is because an ammeter has low resistance on its own and would receive such a high voltage it would burn and destroy it. The Ohmmeter we had to explain why it can not be attached to anything powered. The reason why is that the Ohmmeter supplies its own voltage

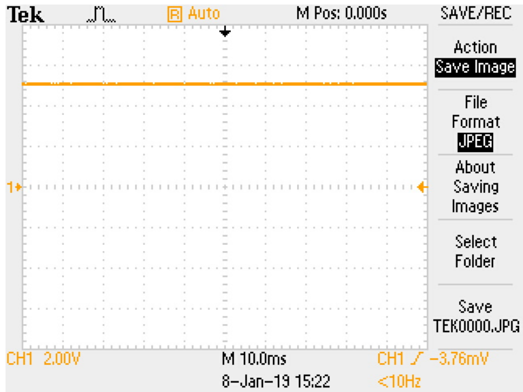

Figure 1: This figure shows the voltage read from the oscilloscope

to measure a regions resistance, if something was powered it would interfere with its readings and give an incorrect resistance.

1.3. Part C

The last beginning exercise was to show the connectivity of the breadboard. The breadboard has 3 buses at the top and to the sides to house the power which flows through the bar. The main board has many perforations to allow for wires to be placed. A drawing of the board was done and there are red bars on top to display the places of disconnection, the rows of boxes show how power flows through perforations of the board when placed in a section and positive and negative polarities of the bars at the side were placed. The drawing visually shows the major components of the breadboard; Figure 2 shows the breadboard drawing.

2. Ohm's Law (1-1)

2.1. Part D

The first part of the main laboratory was to verify Ohms law. This required us to compare two different resistors of 10 kOhms and 20 kOhms, as they are consistent and allow us to have two groups to compare. The next step to verifying ohms law was to send a voltage through a basic circuit consisting of only a resistor that we measured the voltage across for voltages ranging from 1 Volt to 7 Volt. The results are graphed in figures 3 and 4, showing the linear progression of Ohms law

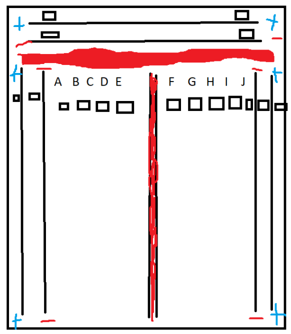

Figure 2: This drawing was done to display the breadboard used during the laboratory and the points of connection

2.2. Part E

The second item of this first part was to find the internal resistance of battery. To do this we first took a current measurement on 1 Volt, through a 100 ohm resistor yielding .26 miliVolt on the DVM. To find the internal resistance we used two methods first we looked at the total voltage and the looked at the different voltage drops across the circuits and added them together and the other was the voltage divider equation. The voltage inputted accurately was 1.021 Volts the voltage outputted by the circuit was .966 Volts inputting into the voltage divider equation show in equation 1.

$$V_{out} = \frac{R_2}{R_1 + R_2} \qquad [1]$$

equation 1 allows us to compute the internal resistance which was 5.7 Ohms.

3. More Exercises

3.1. Part F

Before we proceeded we had to do some more exercises. We measured a 10 Mega OHM resistor with our DVM which yielded a value of 10.12 Mega

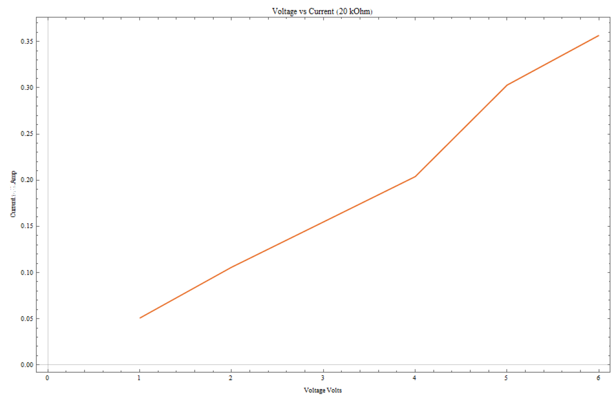

Figure 3: This shows how the voltage vs current moves with the 20kOHM resistor

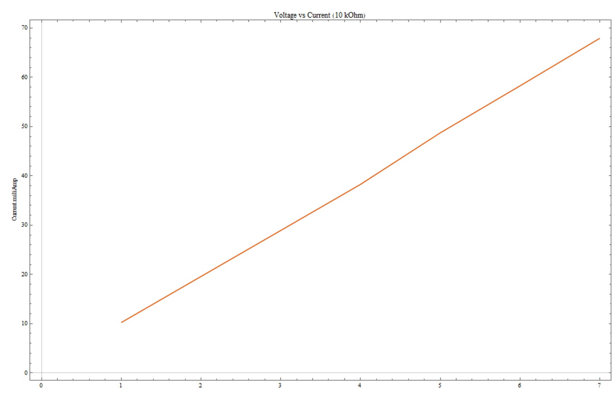

Figure 4: This shows the voltage vs current for the 10kOHM resistor

OHM's. Then we measured the resistor in the circuit which gave us the same value of the DVM in air. The last action we did was try to measure the resistance through our hands, this caused trouble as our reading became 184.7 kilo OHM's. This confirmed for us that you cannot measure the resistance of something through the body, the reason why is that your body acts as a resistor itself that is in parallel and causes measurement errors.

3.2. Part G

Another exercise we had to do before proceeding was calculating a good resistance for a resistor of 1/4 Watt that is facing 5 Volts and 1 Amp output from a power supply. Using OHM's law and the power equation in a circuit a good resistor would be one of 100 OHM's. The equation we used goes as follows

$$P = I^2 R \qquad [2]$$

$$I_{1/4W} = \sqrt{\frac{1}{4R}} \qquad [3]$$

$$V_{1/4W} = \sqrt{\frac{R}{4}} \qquad [4]$$

If you try to dissipate more watts into the resistor it causes the resistor to burn out. We did this by dissipating 8 Watts into the circuit and the resistor began burning immediately.

4. Testing Ohm's law on a lamp (1-2)

4.1. Part H

In an effort to have a consistent view with reality we preform this next part to break Ohm's law. To break Ohms law we analyze a basic circuit only a power source and resistor which in this case is a incandescent light bulb which uses a filament to light and is a material similar to a resistor. We set the voltage to be 5 Volts to 10 Volts with the exception of a 13 and 15 volt measurement. We measured the current with a DVM, and the reason we can see the resistance change is that resistances are typically stable and thus a voltage versus current graph will be linear in this case it had a curve of decreasing strength for the current verifying Ohms law does not hold in all cases.

We are asked what is the resistance of the lamp, if this is reasonable to ask, and why the filament despite being resistor material not displaying its behavior. The reason why it is not reasonable is that this filament heats and thus has a resistance that changes; as atomically electrons cannot move as freely. It can be show a consistent resistance occurs initially but the initial conditions can be different in a variety of ways which is why it is not reasonable to for a definite resistance in this case.

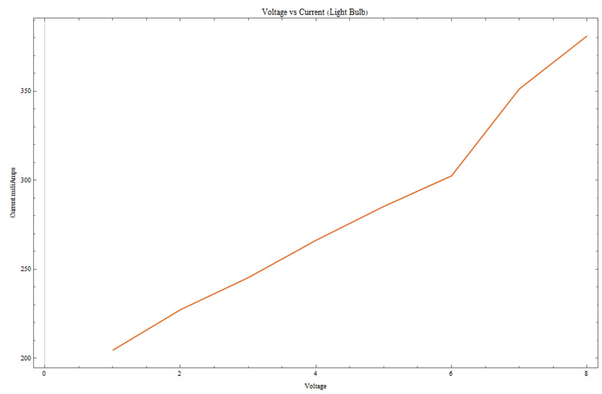

Figure 5: This graph shows the voltage versus current for a incandescent light bulb

5. Testing Ohm's law with diode (1-3)

5.1. Part I

The reason why ohms law is interesting in a diode that the circuit must be done in a parallel manner. The current in this case will be very high with low voltages. The voltages ranged from 350 miliVolts to 750 milivolts, the graphs figures 6 and 7, both correlated and shows the dramatic rise in current and a linear log graph showing a straight line, showing in this case does not obey Ohm's law but follows its own rules.

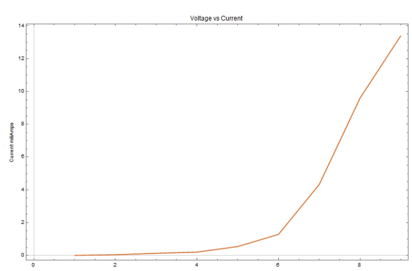

Figure 6: This graph shows the voltage versus current

5.2. Part J

This part was simple, to test the capacity of a diode we had to burn it out. This required us to run 5 Volts across it and watch it burn and stop it before it caused any harm.

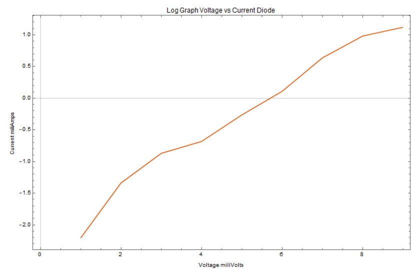

Figure 7: This graph log graph of the voltage versus current

6. Voltage Divider and Thevenin Model (1-4)

6.1. Part K

To get a better understanding of circuits we constructed a complex and then a thevenin reduced circuit. The thevenin model shows that despite the construction and materials used in two circuits are different the overall functionality can remain the same so a thevenin circuit is simpler to use. So we built a circuit with two resistors and placed a voltmeter over the second resistor. The initial power supply to the circuit was 15 Volts though the voltage read at the end was 7.48 Volts. We then placed a 10kOhm resistor as a load to the circuit which then dropped the voltage further to 4.98 Volts. We then shorted the circuit to the ground giving us the short circuit current of 1.5 miliAmps. We then created a thevenin equivalent circuit this meant changing the voltage to 7.5 Volts and using only a single resistor of 5 kOhms. The results were the same the short circuit yielded 1.5 miliAmps and adding the load of 10 kOhm resistor still yielded a voltage drop across of 4.93 Volts. The current through the load resistor to ground was .508 miliAmps and the .5012 through the other parts of the circuit. This shows that the Thevenin equivalent circuit behaves identically to a more complex circuit.

7. Function Generator

7.1. Part L

This part had us input a signal from the Function Generator to a speaker and then drove it with a sinusoidal wave that we could hear. This required us to get the appropriate connectors and then tune the frequencies to human level of hearing which was from 200 Hz to 20 kHz. We also varied the amplitude of the wave to add loudness to our speaker.

8. Oscilloscope (1-5)

8.1. Part M

To get a better understanding of our measuring devices we took a look at the Oscilloscope connected to the Function Generator. The first thing we did was manipulate the vertical gain switch, this is subjected to our first input and controls how large the graph will be. The next item was the horizontal sweep speed which controls the time per division and basically captures the signal for a certain amount of time. Then we manipulated the triggering controls which allows us to focus on the graph at the extremities fine tuning our range of values and making our graph stable. To get a feel for capturing data we captured the rise time of a slope of a graph from 10 % to 90 % that was given from the function generator the result was 19 nanoseconds in our calculations and 14 to 17.5 for the measurement recorded on the oscilloscope which is shown below.

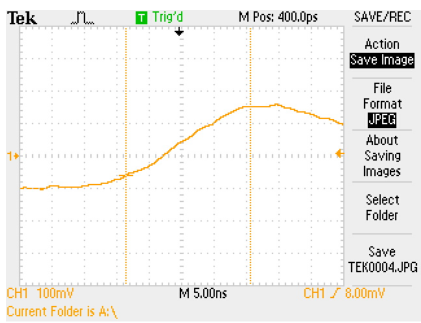

Figure 8: This shows the rise time for a frequency we measured

The next step was to get a better analysis of the triggering and rise time by utilizing the sync out of the function generator giving us a square wave of frequency the sinusoidal wave in channel 1.

Then we began to look at frequencies with the AC and DC switches. We found that the Ac makes the waves struggle to be stable and the DC works perfectly fine but when applying an offset voltage it jumps up on the graph. Directly measuring a frequency on the function generator we have 35.2 kHZ but the oscilloscope had a value that would fluctuate but not dramatically at 35.2 kHZ, the period was 28.5 nanoseconds. To get a good picture of the frequency generator unabated we set it to 10 kHZ and displayed below.

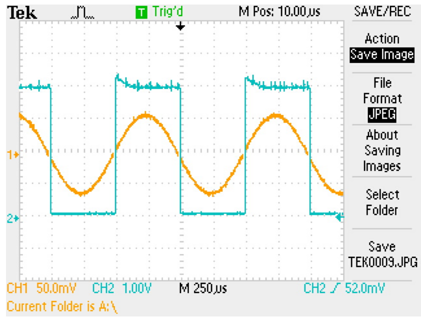

Figure 9: This shows the sync out of the Function generator

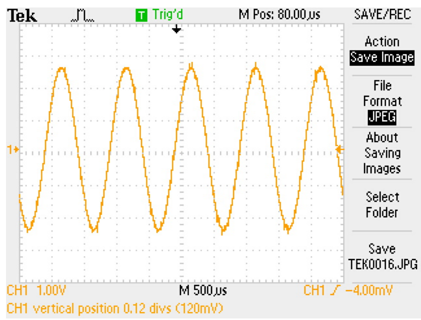

Figure 10: 10 kHZ frequecy displayed on oscilloscope at pulses 1 nanosecond

9. AC Voltage Divider (1-6)

9.1. Part N

The last objective of the lab was to analyze an AC voltage divider. We first had to think how our voltage divider would be effected by an AC source. We could not come up with a significant difference an AC power would carry other than the voltage divider would not be able to read a consistent voltage. Then we hooked up a voltage divider and inputted a 1kHz sine wave. Comparing the input signal to the Output signal we received basically an equivalent source out of phase. To explain this phenomenon, I suppose the voltage divider causes some delay to the system and causes the fluctuations to occur.

10. Conclusion

The purpose of this laboratory was to acquaint ourselves with a variety electrical measuring devices and power supplies. For our measuring devices we familiarized ourselves with a hand held multimeter which was also used to measure various voltages and resistances, and a oscilloscope which was used to interpret frequencies inputted into it. For the power supplies we had a DC power supply which gave the majority of our circuits power and a Function generator which feed our oscilloscope and a speaker frequencies. We began by measuring OHM's law in various situations first with regular resistors, then an incandescent lamp, and then a diode; the purpose of the last two was to show how OHM's law can fail for different reasons. Then we created a circuit that involved multiple resistors that we broke down to a Thevinin equivalent circuit showing how they were the same. The final activity that we carried out was measuring the voltage of a circuit powered by an AC source, we observed how the circuits voltage was fluctuating and that the output signal was equivalent. In the end we gathered very few enlightening ideas but garnered skills that can preputuate our success into more complex labs.