Lab 3: AC Circuits

Kenneth Zhuang

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TA: Janaki Sheth

Lab Section 8

Lab Partners: Frank Chen, Jayendra Jog

Introduction

The purpose of this lab was to investigate the workings of Ohm’s law in both resistor and diode loaded DC circuits by looking at its IV characteristics. A linear relationship will prove Ohm’s law. Further, data analysis techniques like linear regression will be explored in greater depth. To verify Ohm’s law in the resistor’s case, two resistors were connected in series. A voltage is then applied through the arrangement, and the current can be acquired using Kirchhoff’s Current Law. To investigate the properties of Ohm’s law in diodes, one of the resistors was replaced by a diode and the experiment was done again. Ratios between the two voltages were taken from the two experiments. Rectification of half waves were also done in the experiment, as well as linear regression on the data.

Experimental Apparatus and Procedure

For the experiment, a break out box was used to make the circuits for both the resistor and the diode. A function generator was used to apply voltage through the apparatus. Triangular waves were used to apply the voltage across the series connections. A MyDAQ was used to measure the voltage drop across the different components and plots of both channels against time were created. Appropriate sample rates were chosen to acquire respectable data. For the diode circuit, the resistor was then replaced with a resistor with significantly higher values and sine waves were run through it using the function generator. The peak to peak voltage was measured using the oscilloscope.

Analysis

Figure 1: The plot of current vs. voltage is shown. It is visually clear that there is an exponential relationship between the current and the voltage, thereby disobeying Ohm’s law. The error bars present in the plot account for the standard errors present in the measurement for each data point with respect to the mean.

Figure 2: The linearized data for the rectifier is shown. Io was found to have a value of 0.000044. The line of best fit is governed by the equation

|  |  |  |
| --- | --- | --- |
|  | *Coefficients* | *Standard Error* |
| Intercept | -8.687767204 | 0.623314319 |
| Slope | 17.97443436 | 1.13308372 |

Table 1: Linear Regression data for Linearized IV curve for the Rectifier Diode.

The magnitude for the ratio was measured to be Compared to the theoretical magnitude, which has a value of , the values are close to each other. The discrepancies are probably due to the numerous error possibilities present in the experiment. The acquisition of the value Io is fairly arbitrary, as there is no set voltage to stop measuring current values. Errors can also arise from neglecting values not consistent with a linear fit. The diode could also have been malfunctioning.

Half Wave Rectifier

|  |  |  |
| --- | --- | --- |
| Input Voltage (V) | Output Voltage (V) | Efficiency |
| 5 | 4.8 | 0.41 |

Table 2: Input and Output data with Efficiency ratings for the half wave rectifier.

As the input voltage goes through the resistor-diode arrangement, there is some attenuation that happens. This is due to the voltage drop that happens across the diode.

To measure the efficiency, the equation is used. The resistance of the diode is taken to be very small compared to the load resistor, and as such was then neglected.

To get the intrinsic voltage drop, the difference between the input voltage measurement and the output voltage measurement was taken. This applies elements of KVL. It appears that the value is around 0.2 V.

To get the intrinsic value using the IV curve, some physical intuition is needed. As a diode takes voltage across it and then lets the remaining current pass through it without significantly altering its voltage, the graph will show this. Thus, the voltage drop across the diode would be the area between the start of the applied voltage and the point wherein the derivative is close to infinity. No matter how much current passes through it, its voltage remains relatively similar. By eyeballing the graph, the value of the voltage drop is estimated to be around 0.7 to 0.8 V, which is fairly close to the intrinsic voltage measured using the half wave rectifier values. Errors are still present due to the imperfectness of the human sight and the accuracy of the oscilloscope and the function generator used. The diode might also have been broken.

Conclusion

The results of the experiment fulfilled the objectives. An exponential function was measured for the diode and a linear fit was taken. The theoretical value was close to the experimental value as well.

Bibliography

1. Wikipedia. “Boltzmann Constant”. *Boltzmann Constant*. Wikipedia, 22 Jan. 2017, https://en.wikipedia.org/wiki/Boltzmann\_constant