PHYS 605 Lab #6

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I. INTRODUCTION AND THEORY

A. Purpose

In this lab, the focus was to learn about how diodes can be used in AC circuits. The first part of the lab showed how a single diode can be used as a half-wave rectifier. In the second part of the lab the group made a full wave rectifier. In the third part of the lab the behavior of a zener diode was explored both with DC and AC voltage sources.

B. Background / Theory

The lab revolved around the behavior of diodes in AC circuits. Diodes are an interesting type of passive circuit element which have interesting properties. The most important property of diodes is that they only allow current flow in one direction. When an AC voltage source powers a diode, only the positive or negative voltage will go through the diode.

In the Part A of the lab a diode was used to convert the AC signal into only a positive signal. This demonstrated the diode property of only allowing current flow in one direction. When the AC source supplies a positive voltage the diode would allow current flow through. When the voltage source supplies a negative voltage the diode will not let current flow through. The circuit used for this part of the lab was built in two aprts. First the circuit was built with a resistor and a diode in series with the oscilliscope connected in parallel with the voltage source and the diode. After this circuit was investigated a 3V DC supply was added to the circuit between the resistor and diode. The final circuit for this part of the lab is shown below:

In the second part of the lab, the diode was used to allow the positive and negative voltages through while inverting the negative voltage. The circuit used for this part of the lab is shown below:

This caused the output voltage to be all positive and looked similar to a DC output.

FIG. 1: This circuit only supplies postive voltage to the oscilloscope.

FIG. 2: A full wave rectifier with input and output connected to an ocsilloscope

FIG. 3: A circuit built so that the voltage across the capacitor, v_C, can be compared with the voltage from the source, v_{in}. The phase shift ϕ can also be observed.

For the third part of the lab, a zener diode was investigated. The distinction between a regular diode and a zener diode is that a zener diode will allow voltage to pass in both directions, but in the reverse-bias direction, there is a minimum voltage required to cause current flow. This voltage is called the zener voltage.

II. METHODOLOGY

1. Construct RC circuit with oscilloscope as show in figure (1).

2. Adjust the circuit in order to gain some intuition about how the it behaves— vary the resistor, frequency, and capacitor and note the effects.

3. Choose a circuit design such that a range of behavior can be observed while keeping the frequency below 100.

4. Measure and record the voltage drop, V_C, and the phase shift with respect to input, ϕ_C across the capacitor.

5. Measure and record the voltage drop, V_R, and the phase shift with respect to input, ϕ_R across the resistor.

6. Repeat steps (4) and (5) for several (about ten) frequencies spanning multiple orders of magnitude.

III. RESULTS AND ANALYSIS

A. Data

3.065V (DC) first amplitude/frequency: 2.64V f=7.225Hz -V2(max) 1.78V
second amplitude: 4.08V f=7.225Hz -V2(max) 2.72V
second frequency: 2.64V f=0.732Hz -V2(max) 960mV
third frequency: 2.64V f=74.63Hz -V2(max) 1.76V
fourth frequency: same for higher
WITH DIODE AND +3V
first: 2.64V 731.0mHz V2 464mV
second: 2.64V 74.63Hz V2 480mV
third: 1.48V f=7.225 v2 460mV

B. Calculations

The impedance of the capacitor, Z_C, and the impedance of the resistor, Z_R, could be calculated using equations (1) and (2).

$$Z_R(\omega) = 10\,000$$

$$Z_C(\omega) = \frac{1}{j\omega\ 4.7 \times 10^{-6}}$$

Using equation (6), the gain was calculated, first with the ratio of the voltages, then using the impedances where Z_2 was the impedance of the capacitor and Z_1 was the impedance of the resistor. This allowed us to calculate error.

f [Hz]	$Gain_{measured}$	$Gain_{expected}$	% Error
10.92	-10.4	-12.5	16.8
24.04	-16.8	-18.17	7.53
71.73	-24.6	-26.9	6.92
97.66	-28.9	-29.5	2.03
337.8	-39.2	-40.1	2.24
757.4	-48.9	-47.0	4.68
1 066	-48.9	-50.0	2.20
5 102	-55.7	-63.6	12.4
12 990	-57.6	-72.7	20.8

C. Analysis

Observing the circuit's behavior qualitatively demonstrated that increasing resistance and decreasing capacitance causes an increase in the voltage across the capacitor. It also showed that a change in capacitance will change the phase shift, but a change in resistance will not.

The variation in error for the attenuation suggests that a substantial portion of the error was due to the oscilloscope. There was also more error at the lowest frequencies and highest frequencies. This could be due to less accurate measurements being made when the voltage across the capacitor was very small.

FIG. 4: A Bode plot of the data. The measured values are in blue, while the expected values from equations (6) and (7) are in red.

Using the data collected, a Bode plot was drawn. It is apparent that all of the measured values are after the so-called "-3 dB Point" as the gain plot is definitively negative.

The phase shift plot seemed slightly more erratic. Because the plot is after the -3 dB point, it is expected that the phase will begin to approach 90°.

A line was fit to the gain plot, and the slope showed that the roll off of the transfer function is 16.24 dB/decade.

IV. CONCLUSION

The relationship between frequency, impedance, and voltage was made obvious, and observations matched expectations based on known equations. The resulting improved understanding and intuition for a new type of circuit makes this successful.

Measured values of gain were compared to calculated values with some error, which seemed to increase at extreme values. The roll off was calculated, and the group was able to observe the behavior of a RC circuit in frequencies that were a part of the filtered frequencies.