

# PHYS 605 Lab #6

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## I. INTRODUCTION AND THEORY

### A. Purpose

The goal of this lab was to learn about the use of diodes 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, a full wave rectifier was constructed. Lastly, the behavior of a zener diode was explored both with DC and AC voltage sources.

### B. Background / Theory

Diodes are passive circuit elements that allow current to flow in only one direction. As a result, when a diode supplied voltage with an AC power supply, current will flow only half of the time. Additionally, there is a small voltage drop associated with diodes, usually 0.06V.

A half wave rectifier uses diodes to let only positive voltage from an AC power source through. A DC power supply can also be added (as shown in figure (1)) to modify the behavior. Here, when the input voltage is negative, the measured voltage will be zero because the voltage will flow through the diode and it will be as though the circuit is short circuited. When the input voltage is positive and less than the DC voltage,

Diodes can also be used to construct a full wave rectifier, shown in figure (2), which allows the positive and negative voltages through while inverting the negative voltage.

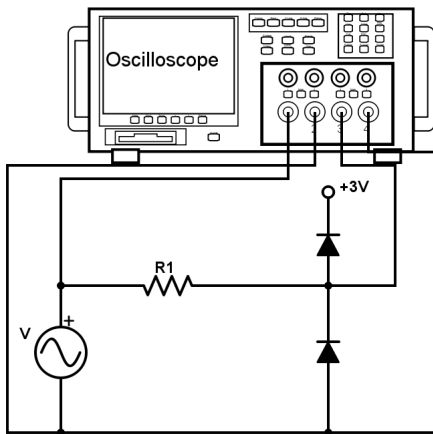


FIG. 1: This circuit only supplies positive voltage to the oscilloscope.

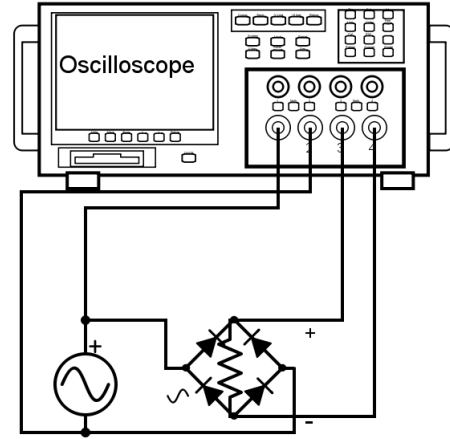


FIG. 2: A full wave rectifier with input and output connected to an oscilloscope

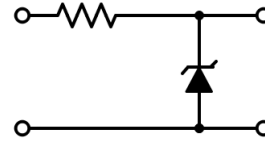


FIG. 3: This circuit only supplies positive voltage to the oscilloscope.

The circuit makes all the voltage positive. As positive voltage is supplied to the circuit current will pass through the top left diode and not the bottom left because of the orientation of the diode. Current will then flow down through the resistor and not the top right diode. As negative voltage is supplied to the circuit current will flow from the bottom side of the AC source. As the current flows to the right side of the bridge it will pass through the top right diode and not the bottom right. The current will then flow down through the resistor as it did when a positive voltage was supplied. This combination will cause flow in only one direction through the resistor and the output of the bridge.

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. A diagram of the circuit for this part of the lab is shown below:

The left side was connected to both DC and AC sources

to investigate different properties of the zener diode.

## II. METHODOLOGY

1. Construct RC circuit with oscilloscope as show in figure (1) without the 3V DC source and diode attached.
2. Take record of the plot from the oscilloscope.
3. Adjust frequency and amplitude of input source and repeat step 2.
4. Build diode bridge shown in figure (2).
5. Connect input source (one that is external from the protoboard) and connect the oscilloscope as shown in figure (2).
6. Repeat steps 2 and 3 to get data about the bridge.
7. Construct the circuit shown in figure (3).
8. Add an adjustable DC input to the left side of the circuit and connect a measurement device to the right side of the circuit.
9. Make recordings of the output voltages as the input voltage is modified.
10. Swap the DC input for an AC input and swap the measurement device for one suited for AC voltages (oscilloscope) if necessary.
11. Take record of the plot shown on the oscilloscope.
12. Swap the zener diode out for another one and repeat step 11.
13. Combine the two diodes in series in the same direction and make record of the plot on the oscilloscope.
14. Combine the two zener diodes in parallel in opposite directions to "clip" both positive and negative voltages from the AC input.

## III. RESULTS AND ANALYSIS

### A. Data

For part A of the lab, first only part of the circuit was built as described previously. This setup was investigated with varying voltages and frequencies for the input source. All voltages for  $V_{in}$  and  $V_{out}$  were maximum voltages.

The input source was initially set to an amplitude and frequency of 2.64V and 7.225Hz respectively. The  $V_{out}$  for the diode was 1.80V.

The group then increased the amplitude of the input voltage to 4.08V. The resulting  $V_{out}$  was 2.72V.

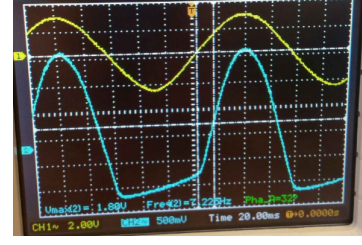


FIG. 4:  $V_{in} = 2.64V$   $f=7.225Hz$   $V_{out} = 1.80V$

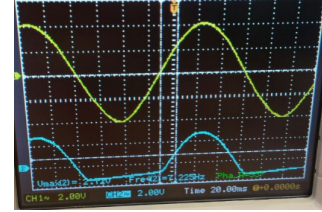


FIG. 5:  $V_{in} = 4.08V$   $f=7.225Hz$   $V_{out} = 2.72V$

The group then reset the input voltage to 2.64V and increased the frequency to 75.19Hz. The resulting  $V_{out}$  was 1.76V

After adjusting the amplitude and frequency of the input voltage a 3.065V DC source was added to the circuit attached by another diode as shown in figure (1).

The group then decreased the voltage of the input source to 1.48V and set the frequency to 7.225Hz as it was initially. The resulting  $V_{out}$  was 460mV

The group increased the frequency to 74.63Hz and the voltage to 2.64. The resulting  $V_{out}$  was 480mV

### B. Analysis

For part A of the lab the voltage across a single diode was measured with varying input voltages. When only an AC voltage source was connected to the diode and a resistor that were in series the result was half of a sine wave as expected because the diode only allows current flow in one direction. The current will flow only in the negative direction which will cause the voltage across the oscilloscope to be equal to the diode voltage. When current cannot flow through the diode almost all of the voltage is

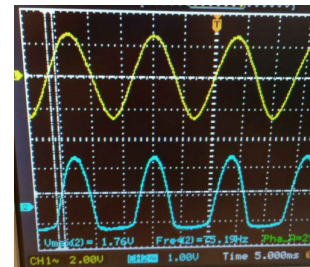


FIG. 6:  $V_{in} = 2.64V$   $f=75.19Hz$   $V_{out} = 1.76V$

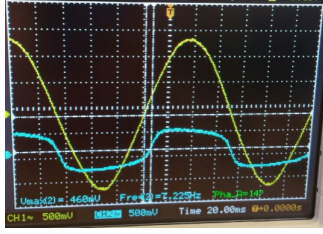


FIG. 7:  $V_{in} = 1.48V$   $f=7.225Hz$   $V_{out}= 460mV$

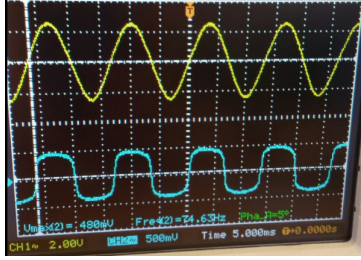


FIG. 8:  $V_{in} = 2.64V$   $f=74.63Hz$   $V_{out}= 480mV$

across the oscilloscope. This means that when the voltage of the input source is positive the voltage across the oscilloscope is equal to the input voltage.

When the amplitude of the input source was increased, the straight line looked more flat because it was the same magnitude as before but the amplitude of the positive curve was larger.

As the frequency was increased the plot looked more like a DC source that was turning on and off because the diode voltage was reached faster reducing the curve on the bottom of the voltage plot.

After the 3.065V DC source was added with the diode as shown in figure (1). The amplitude of the oscillations

of voltage across the diode were now flat on top and bottom. When a negative input voltage was supplied current flowed through the resistor and the voltage across the resistor was equal to the diode voltage. When the voltage of the input source was positive the 3.065V from the DC source consumed the input voltage. Since the input voltage never reached greater than 3V, the output voltage was zero. If the voltage of the input had been greater than 3V then the voltage across the oscilloscope would have been equal to 3V.

When the frequency was increased, the plot flattened out on top and bottom and looked again like a DC input that was flickering up and down by 480mV. This makes sense as the diode will vary between the diode voltage and zero. When frequency is increased the diode voltage is reached more quickly and therefore makes the plot look more flat.

#### IV. CONCLUSION

The first part of the lab was completed successfully as the group was able to demonstrate that a diode can be used to create close to half of a DC voltage supply. The group discovered that for higher frequency input voltages the plot was more flat on top and bottom. The correct properties of the diode were demonstrated in this part of the lab. When then 3V DC source was added, the results were accurate as the voltage varied between zero and the diode voltage. This is what would have been expected for input voltages below 3V. The mistake of the lab group was not to vary the input voltage much higher to demonstrate that when the voltage supply is greater than 3V, the voltage across the oscilloscope will be capped at 3V. This part of the lab was only partially complete. The results for what was done were as expected.