

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 reference voltage 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.

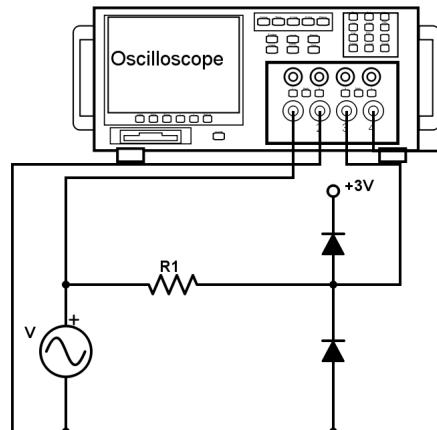


FIG. 1: This circuit only supplies positive voltage to the oscilloscope.

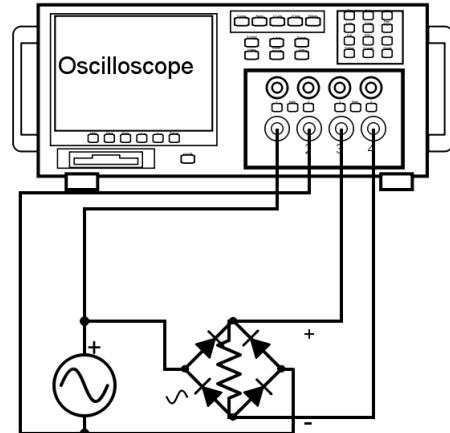


FIG. 2: A full wave rectifier with input and output connected to an oscilloscope

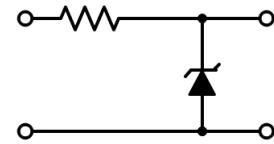


FIG. 3: This circuit only supplies positive voltage to the oscilloscope, attached to the right terminals. The power source was connected to the left-side terminals.

The circuit makes all the voltage positive. As positive voltage is supplied, 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.

Zener diodes are a kind of diode that will allow current to flow in the reverse-bias direction if the voltage is above a certain minimum voltage. This voltage is called the Zener voltage.

Zener diodes allow only the Zener voltage to pass

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

The half wave rectifier was investigated with various input voltages and frequencies. All voltages for V_{in} and V_{out} were maximum voltages.

The input source was initially set to an amplitude of 2.64V and frequency 7.225Hz. The V_{out} measured across 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.

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

The reference voltage added was a 3.065V DC source, constructed in the manner shown in figure (1).

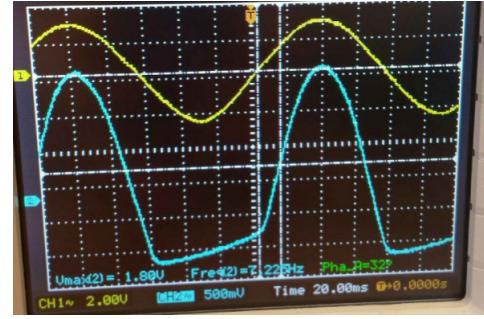


FIG. 4: $V_{in} = 2.64V$, $f = 7.225Hz$, $V_{out} = 1.80V$

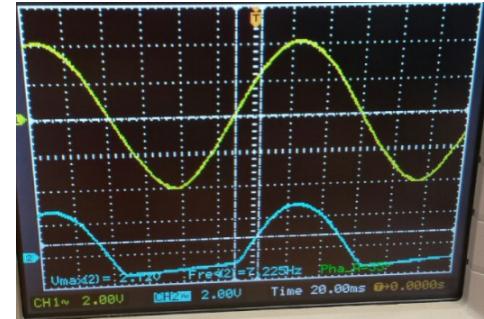


FIG. 5: $V_{in} = 4.08V$, $f = 7.225Hz$, $V_{out} = 2.72V$

The input voltage was decreased to 1.48V, and the frequency was set to 7.225Hz. 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.

The full wave rectifier was built, as in figure (2), using a $98.6k\Omega$ resistor.

The circuit shown in figure (3) was built using a $2.219k\Omega$ resistor. First, the Zener diode's behavior was observed as input voltage was varied.

Two Zener diodes in series in the same direction acted the same as one.

One Zener diode resulted in the clipping of the negative voltage. Two Zener diodes in opposite directions resulted in the clipping of both positive and negative voltages.

B. Analysis

When only an AC voltage source was connected to the diode and resistor that were in series, the result was half of a sine wave. This was what was 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 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.

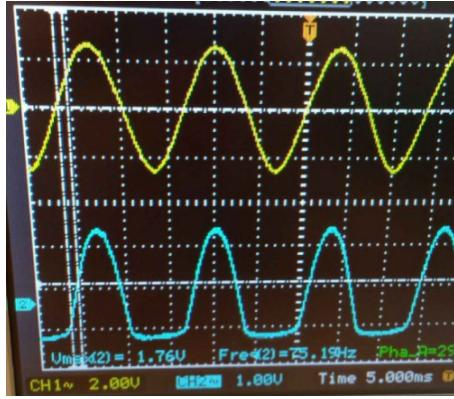


FIG. 6: $V_{in} = 2.64V$, $f = 75.19Hz$, $V_{out} = 1.76V$

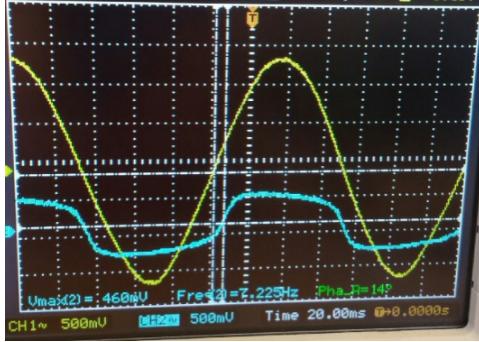


FIG. 7: $V_{in} = 1.48V$, $f = 7.225Hz$, $V_{out} = 460mV$

When the amplitude of the input source was increased, the slight angle of linear portion of the plots appeared to decrease, as the larger amplitude of the positive curve made the slant relatively smaller. As the frequency was increased the plot looked almost 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.

When the reference voltage was added, the sinusoidal voltage across the diode became flat on top and bottom, looking much like a square wave. When a negative input voltage was supplied, current flowed through the resistor and the voltage across the diode 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. The input voltage was never greater than 3V, and so the output voltage was 0V. 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 was expected to vary between the diode voltage and zero. When frequency was increased the diode voltage was reached more quickly and therefore makes the plot look flatter.

The full wave rectifier, output shown in figure (9), be-

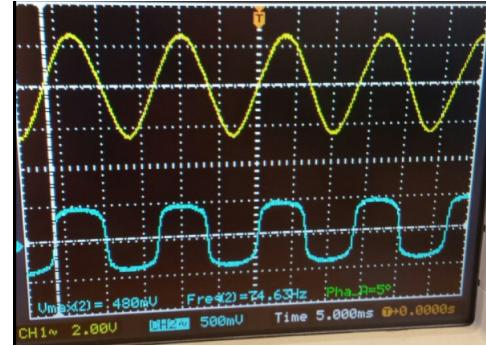


FIG. 8: $V_{in} = 2.64V$, $f = 74.63Hz$, $V_{out} = 480mV$

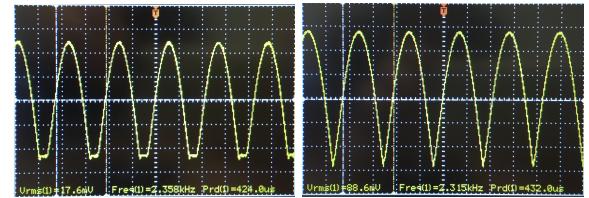


FIG. 9: Full bridge rectifier at about 2.3kHz, the first with a smaller input voltage, the second with a larger input voltage.

haved as expected. The output voltage looked like a sine wave where all of the negative values had been turned positive. At lower input voltages, the voltage would stay near zero before continuing with the positive sine wave. This was because it took some time for the voltage to overcome the diode voltage. The effect was less noticeable at larger amplitudes at the same frequency because the voltage gets larger more quickly.

Lastly, the behavior of Zener diodes was also as expected. It let DC voltage through in the positive bias direction the same way a wire would. In the opposite direction, the voltage stayed nearly constant at what must be the Zener voltage, shown in figure (10). With AC voltage applied to a single Zener diode, the negative voltage was clipped. The negative voltage was the reverse bias direction, so when the input voltage was greater than the Zener voltage, only the Zener voltage was output. It was found that two Zener diodes in series in the same direction acted the same as one diode, with a small added voltage drop. When AC voltage was applied to two Zener diodes in series facing opposite directions, both the positive and negative voltages were clipped at the Zener voltage. With two Zener diodes, the voltage is always in the reverse bias direction for one of the diodes. These expected results were consistent with the actual results shown in figure (11).

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

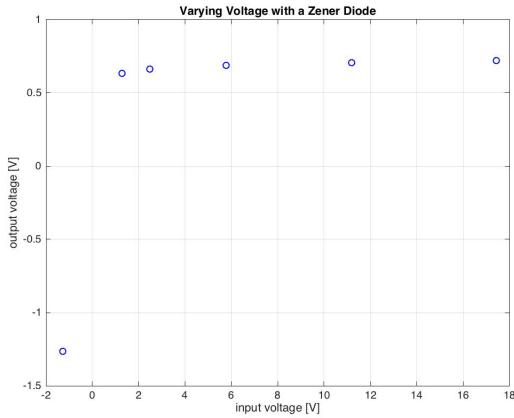


FIG. 10: Zener diode's response to varying voltage.

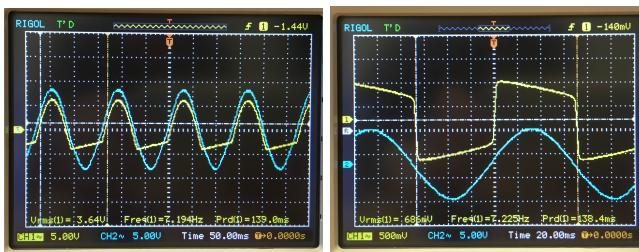


FIG. 11: Left: single Zener diode clipping negative voltage. Right: two Zener diodes in opposite directions clipping both positive and negative voltage.

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. Results for voltages above 3V were not obtained. This could be done in future labs.

A full wave rectifier was successfully constructed. Its behavior was as expected, creating an all positive voltage output by inverting the negative input voltage.

The Zener diode portion of the lab was also successful. The Zener voltage behavior was observed by measuring the output voltage while varying the DC input voltage. Then the clipping effect of the Zener diode on half of the waveform was observed by providing a single Zener diode with an AC voltage input. Then, using two diodes in opposite bias directions, the both the positive and negative output voltages were clipped.

Overall, the lab was completed with a large degree of success.