Pedro Cabrera

Experiment 2

Diode Applications

Half-Wave and Full-Wave Rectifiers

Introduction:

In this laboratory experiment, we set out to explore the fundamental role of diodes in the rectification process, with a particular focus on half-wave and full-wave rectifier configurations. Our objective is to construct these rectifier circuits and analyze their ability to convert alternating current (AC) into direct current (DC). This involves a detailed examination of the diode's unidirectional conductivity and its effect on the shape and amplitude of the output signal. Through the assembly and testing of these circuits, we aim to observe the practical application of theoretical principles such as forward and reverse bias of diodes and their impact on circuit performance.

The experiment is structured to compare the output waveforms of each rectifier type against the input AC signals, allowing us to evaluate the efficiency and potential applications of each rectifier in real-world scenarios. Additionally, we will delve into the role of filtering capacitors in smoothing the output signal of the full-wave rectifier, thereby understanding the trade-offs between ripple voltage and capacitor size.

This hands-on experience, augmented by insights from our course lectures and supplementary academic research, is expected to deepen our comprehension of power conversion techniques and their critical importance in electronic device functionality. Ultimately, through this lab, we anticipate enhancing our technical acumen and analytical skills, equipping us to tackle complex problems in the field of electronics and power supply design.

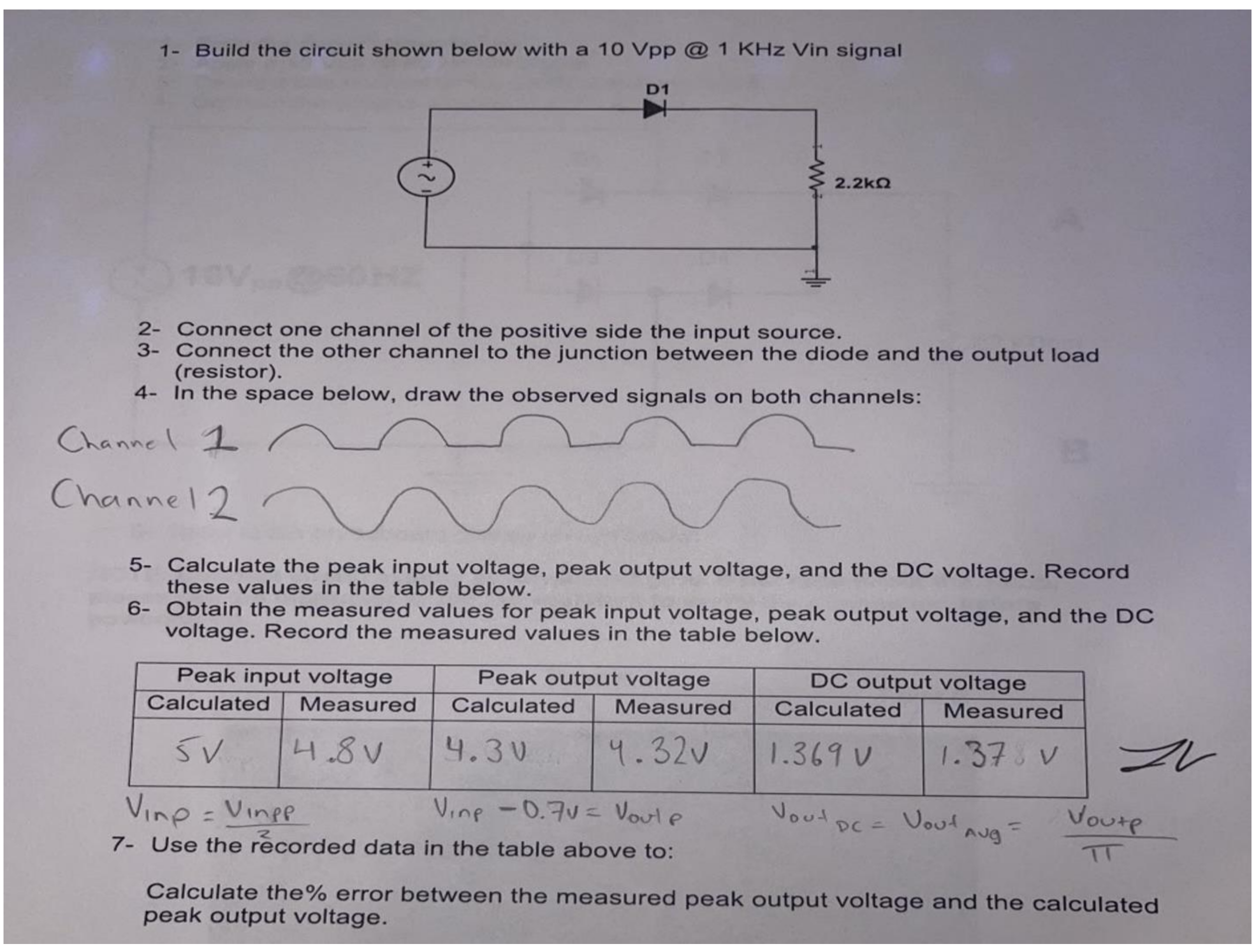
Bench Parts and Equipment List:

1. Components:
    - Diodes (1N4001)
    - Resistor (2.2 kΩ)
    - Capacitor (0.22 µF for the filter capacitor experiment)
2. Equipment:
    - Function Generator

- Oscilloscope
- Breadboard (for circuit assembly)
- Multimeter (for measuring voltage and resistance, if used)
- Wires and connectors (for circuit connections)

Discussion:

Half-Wave Rectifier: The data collected from the half-wave rectifier experiment revealed a distinct rectification of the input sine wave, evident from the output waveform observed on the oscilloscope. The theoretical expectation that the negative portion of the AC cycle would be eliminated was confirmed, as the oscilloscope displayed only the positive half-cycles. This aligns with the theory of diode operation, which allows current to flow only during the positive half-cycles when the diode is forward-biased. The observed voltage drop across the diode was consistent with the silicon diode's characteristic forward voltage, further supporting theoretical predictions.



1- Build the circuit shown below with a 10 Vpp @ 1 KHz Vin signal

2- Connect one channel of the positive side the input source.
3- Connect the other channel to the junction between the diode and the output load (resistor).
4- In the space below, draw the observed signals on both channels:

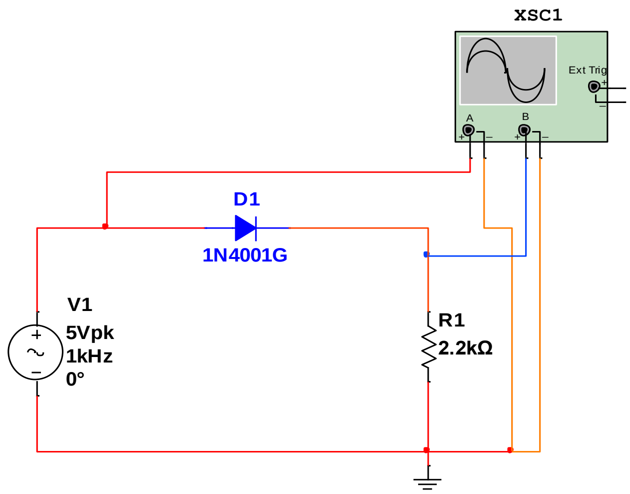
5- Calculate the peak input voltage, peak output voltage, and the DC voltage. Record these values in the table below.
6- Obtain the measured values for peak input voltage, peak output voltage, and the DC voltage. Record the measured values in the table below.

Peak input voltage		Peak output voltage		DC output voltage	
Calculated	Measured	Calculated	Measured	Calculated	Measured
5V	4.8V	4.3V	4.32V	1.369V	1.378V

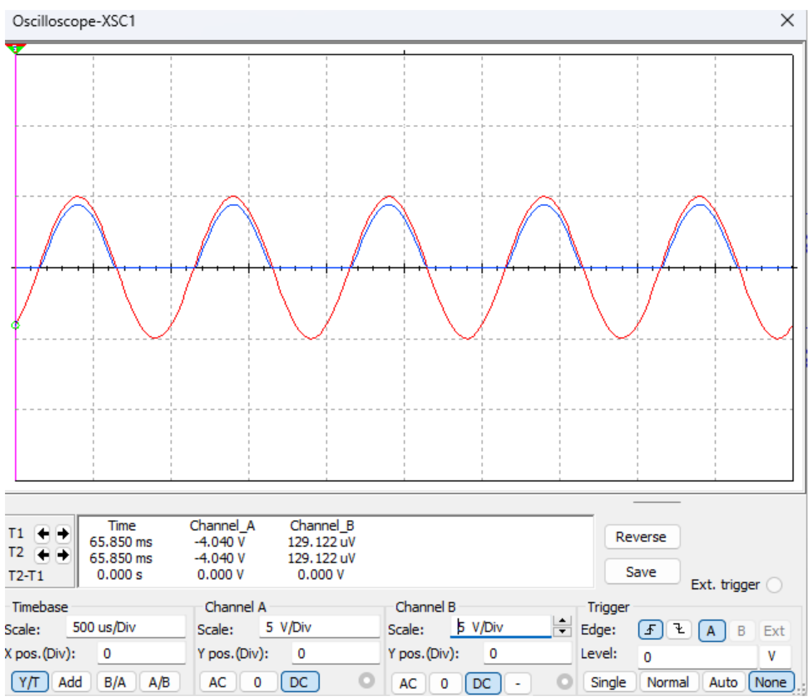
$V_{inp} = \frac{V_{inpp}}{2}$ $\quad V_{inp} - 0.7V = V_{outp}$ $\quad V_{out\,DC} = V_{out\,Avg} = \frac{V_{outp}}{\pi}$

7- Use the recorded data in the table above to:

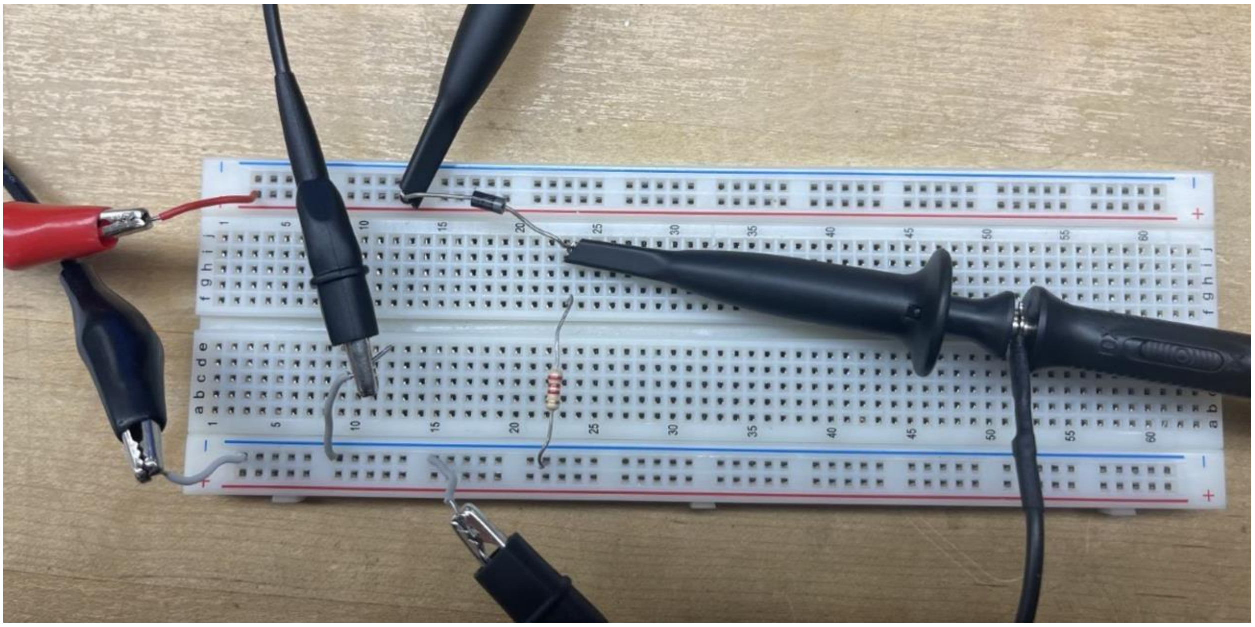
Calculate the% error between the measured peak output voltage and the calculated peak output voltage.



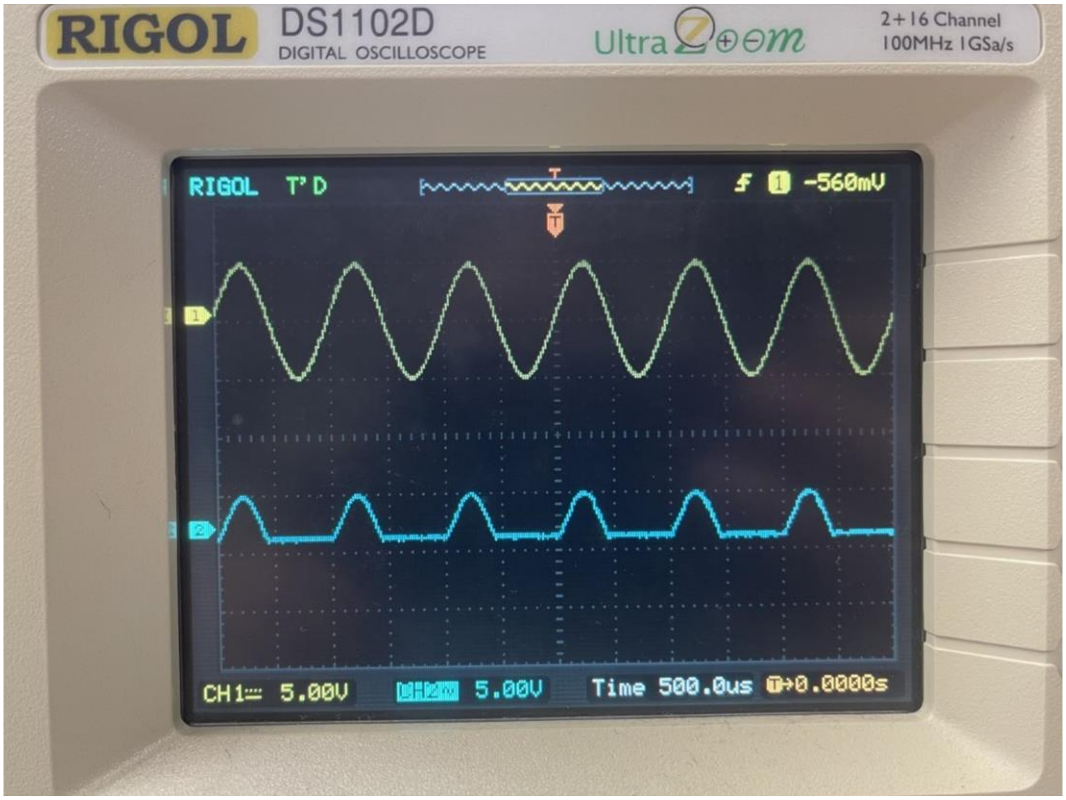
(Figure 1) Half Wave Rectifier Multisim Circuit



(Figure 2) This is the Multisim Half-Wave Rectifier



(Figure 3) Half-Wave Rectifier Bench



(Figure 4) Half-Wave Rectifier Oscilloscope Bench

(Figure 5) DC output Voltage DMM Validation

Table 1

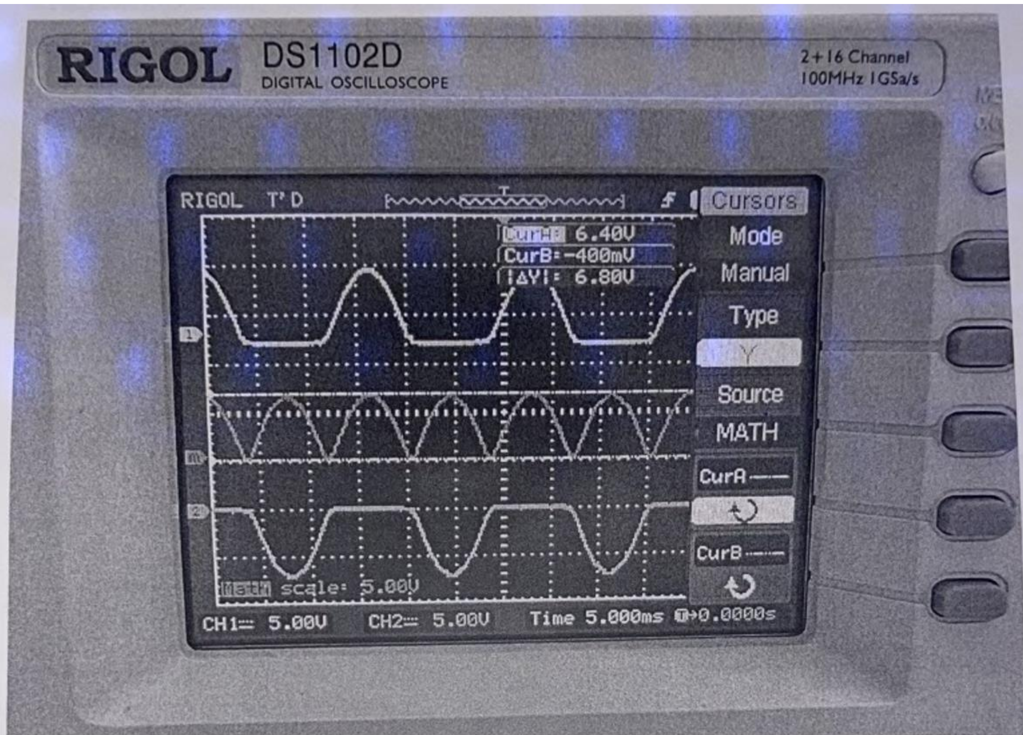
Peak input voltage		Peak output voltage		DC output voltage	
Calculated	Measured	Calculated	Measured	Calculated	Measured
5 V	4.8 V	4.3 V	4.32 V	1.39 V	1.37 V

$$Percent\ Error = \left|\frac{Measure\ Value - Theoretical\ Value}{Theoretical\ Value}\right| * 100\%$$

$$Percent\ Error = \left|\frac{4.32\ V - 4.3\ V}{4.3\ V}\right| * 100\ \%$$

$$Percent\ Error = \left|\frac{0.02}{4.3}\right| * 100\% = 0.4651\ \%$$

Full-Wave Rectifier: In the full-wave rectifier setup, the data showed that both halves of the AC cycle were utilized, resulting in an output frequency double that of the input AC signal. This was anticipated and is a key theoretical aspect of full-wave rectification. The effectiveness of the bridge configuration was evident, as it allowed the current to flow through the load resistor during both halves of the cycle, confirming the circuit's ability to produce a more constant DC output than the half-wave rectifier.

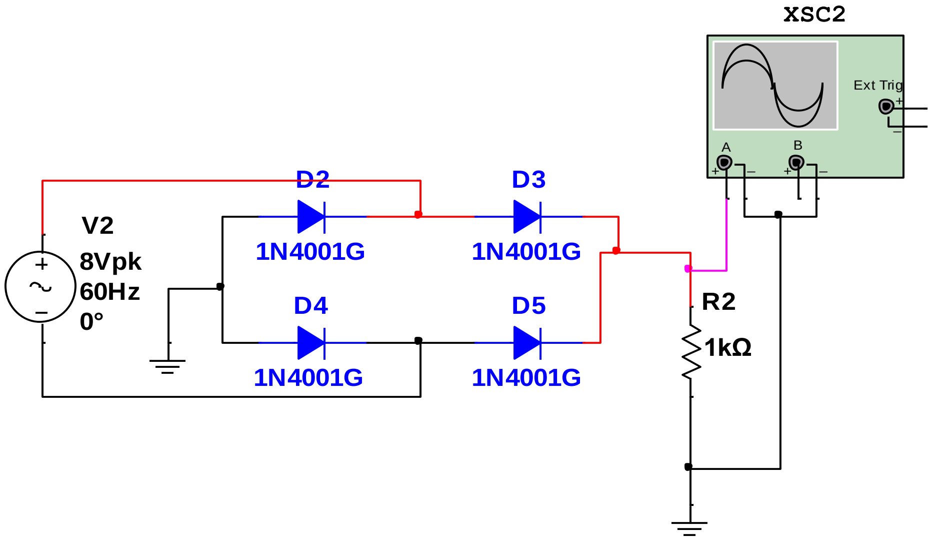


7- Determine the calculated values for peak input voltage, peak output voltage, and the DC voltage. Record the values in table below.
8- Obtain the measured values for peak input voltage, peak output voltage, and the DC voltage. Record the values in the table below:

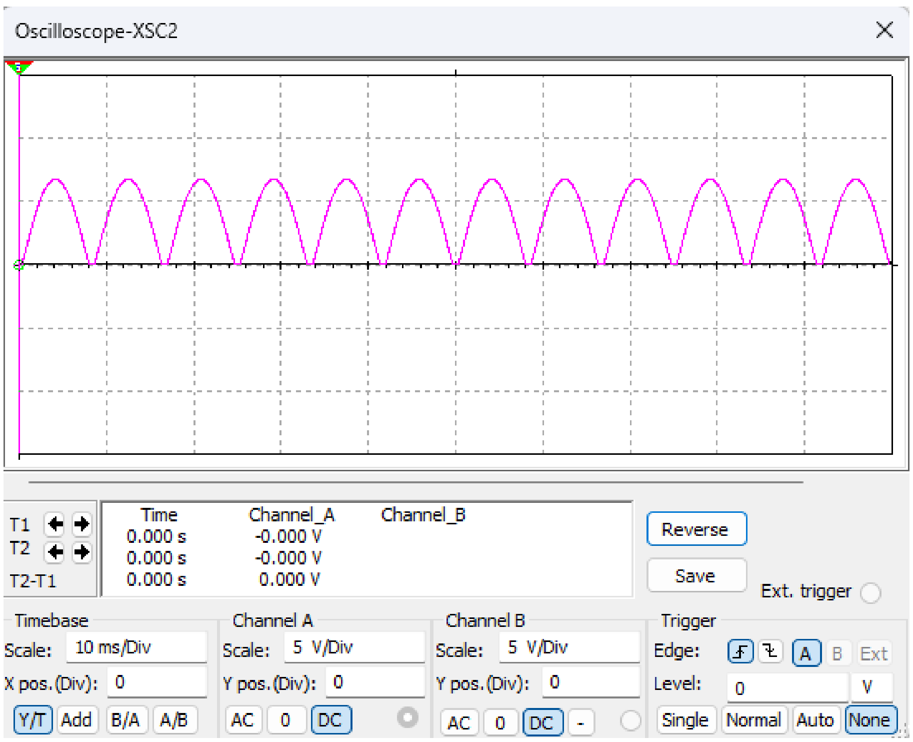
Peak input voltage		Peak output voltage		DC voltage	
Calculated	Measured	Calculated	Measured	Calculated	Measured
8 V	7.8 V	6.6 V	7 V	4.2 V	4.45 V

2V

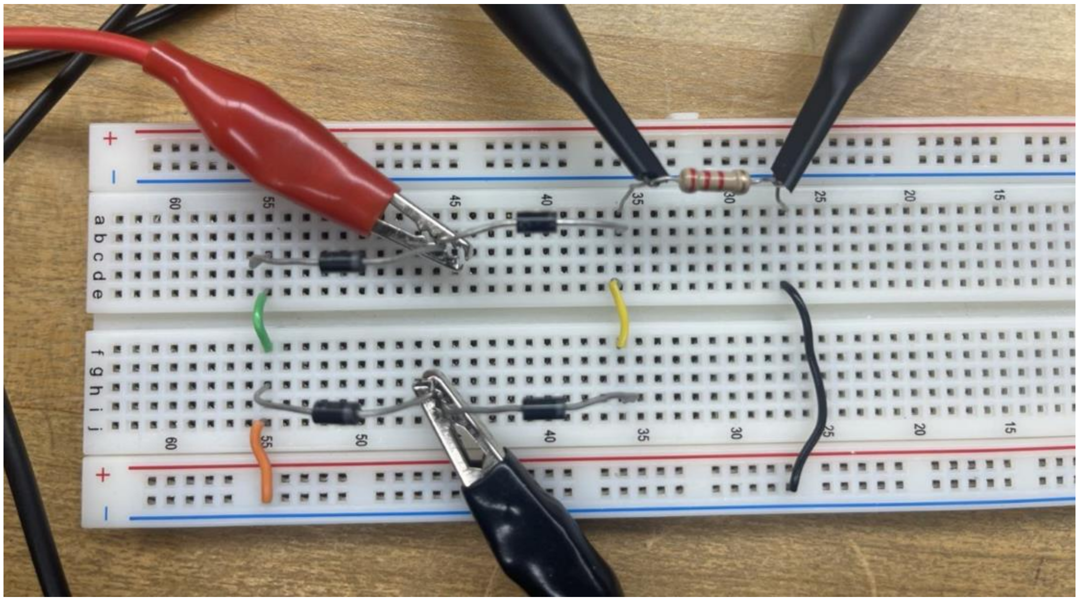
$\frac{V_{inpp}}{2}$ $V_{inpp} - 1.4V$ $\frac{2V_{outp}}{\pi}$



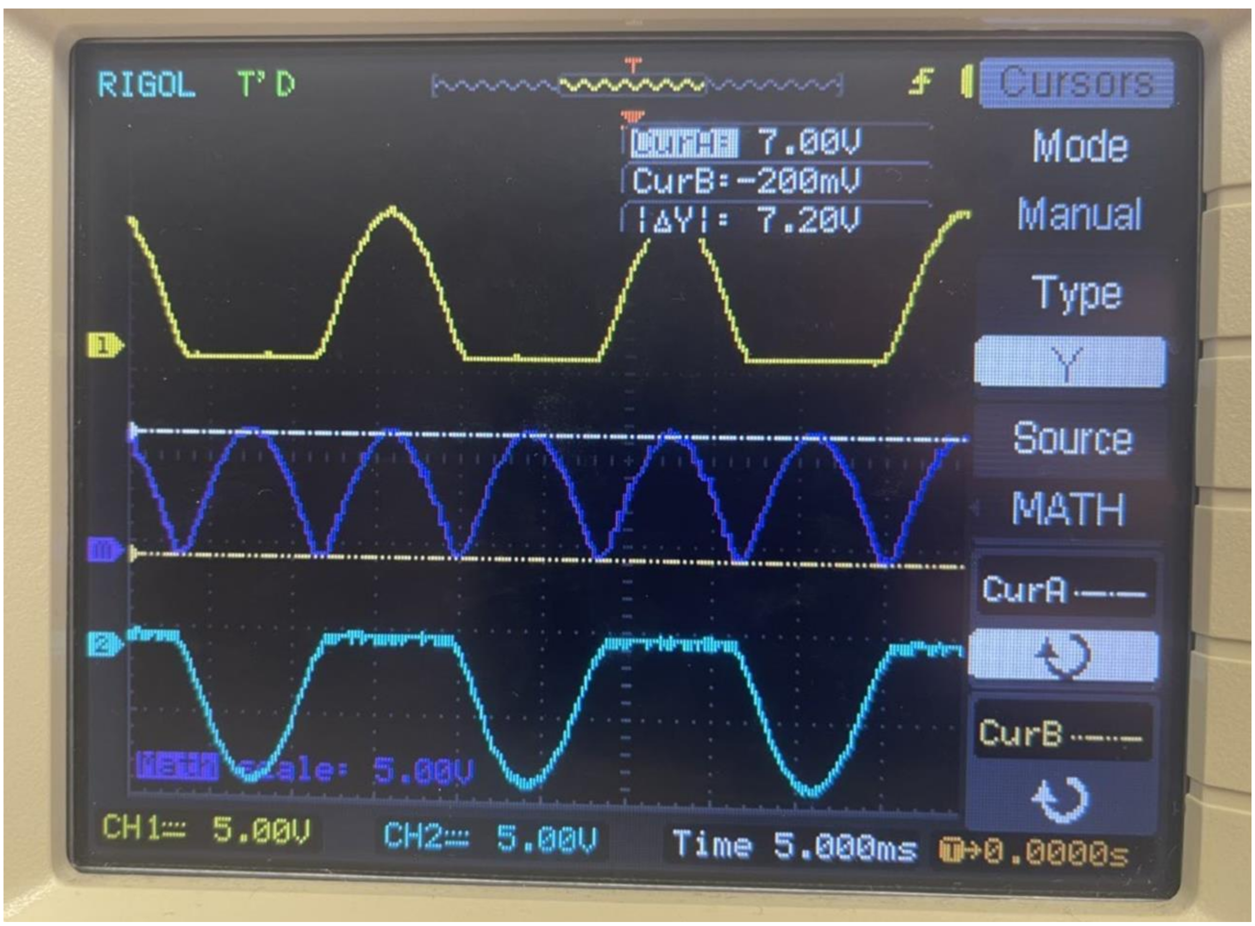
(Figure 6) Full-Wave Rectifier Multisim



(Figure 7) Full-Wave Rectifier Oscilloscope Multisim



(Figure 8) Full-Wave Rectifier Bench

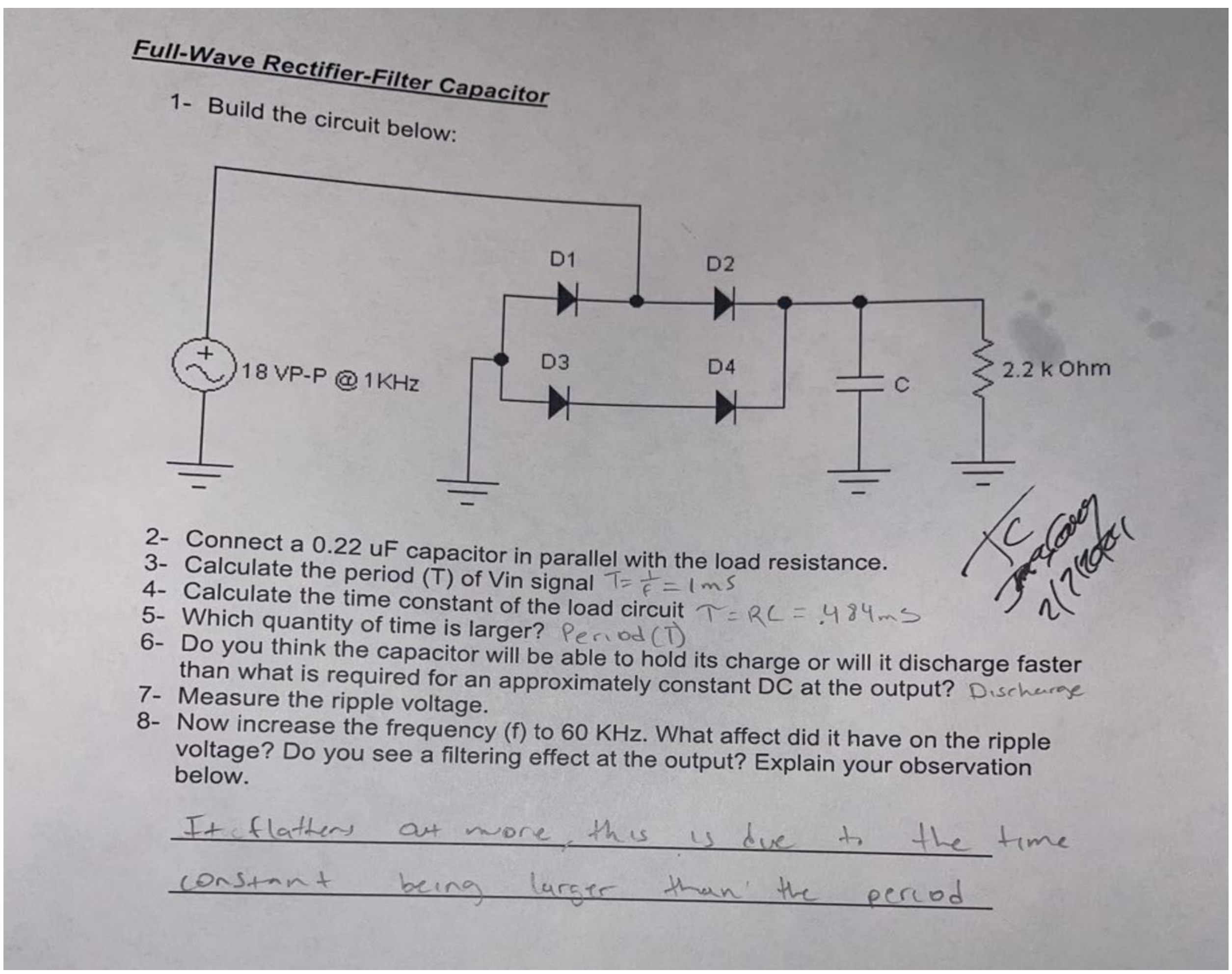


(Figure 9) Full-Wave Rectifier Oscilloscope Bench

Table 2

Peak input voltage		Peak output voltage		DC output voltage	
Calculated	Measured	Calculated	Measured	Calculated	Measured
8 V	7.8 V	6.6 V	7 V	4.2 V	4.45 V

Full-Wave Rectifier with Filter Capacitor: Upon adding a filter capacitor to the full-wave rectifier, a significant reduction in the ripple voltage was recorded. The capacitor charged during the peaks of the full-wave rectified voltage and discharged when the input voltage dropped, smoothing the output signal. This observation was in line with the capacitor's theoretical role as a filter. However, the actual ripple voltage measured was slightly higher than the calculated values, possibly due to the capacitor's real-world performance variances or limitations in the breadboard setup.

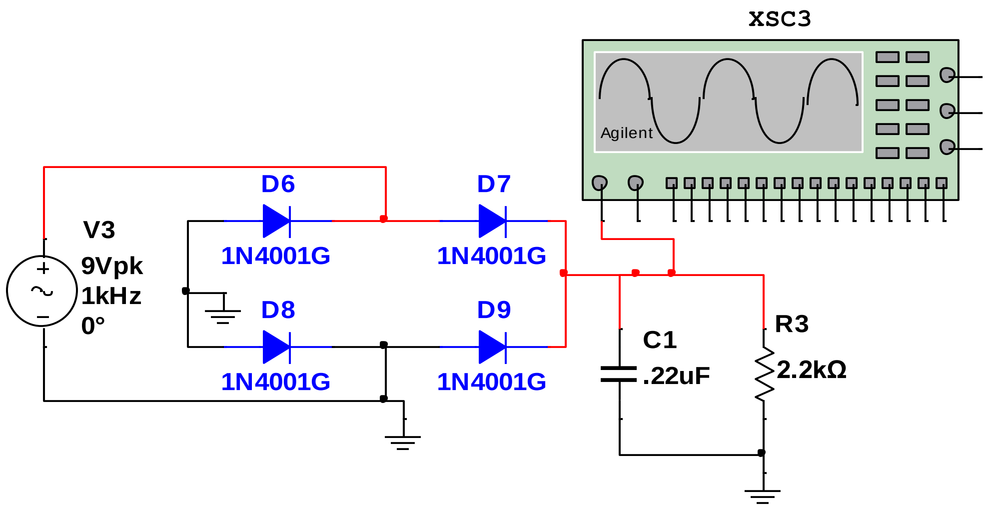


Full-Wave Rectifier-Filter Capacitor

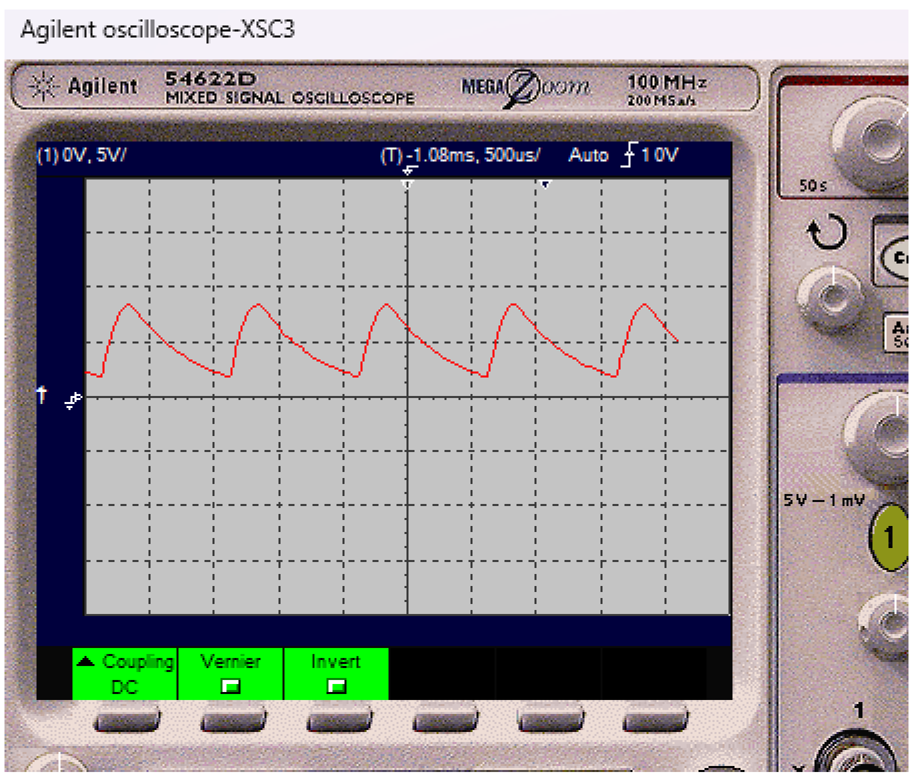
1- Build the circuit below:

2- Connect a 0.22 uF capacitor in parallel with the load resistance.
3- Calculate the period (T) of Vin signal $T = \frac{1}{f} = 1ms$
4- Calculate the time constant of the load circuit $\tau = RC = .484ms$
5- Which quantity of time is larger? Period (T)
6- Do you think the capacitor will be able to hold its charge or will it discharge faster than what is required for an approximately constant DC at the output? Discharge
7- Measure the ripple voltage.
8- Now increase the frequency (f) to 60 KHz. What affect did it have on the ripple voltage? Do you see a filtering effect at the output? Explain your observation below.

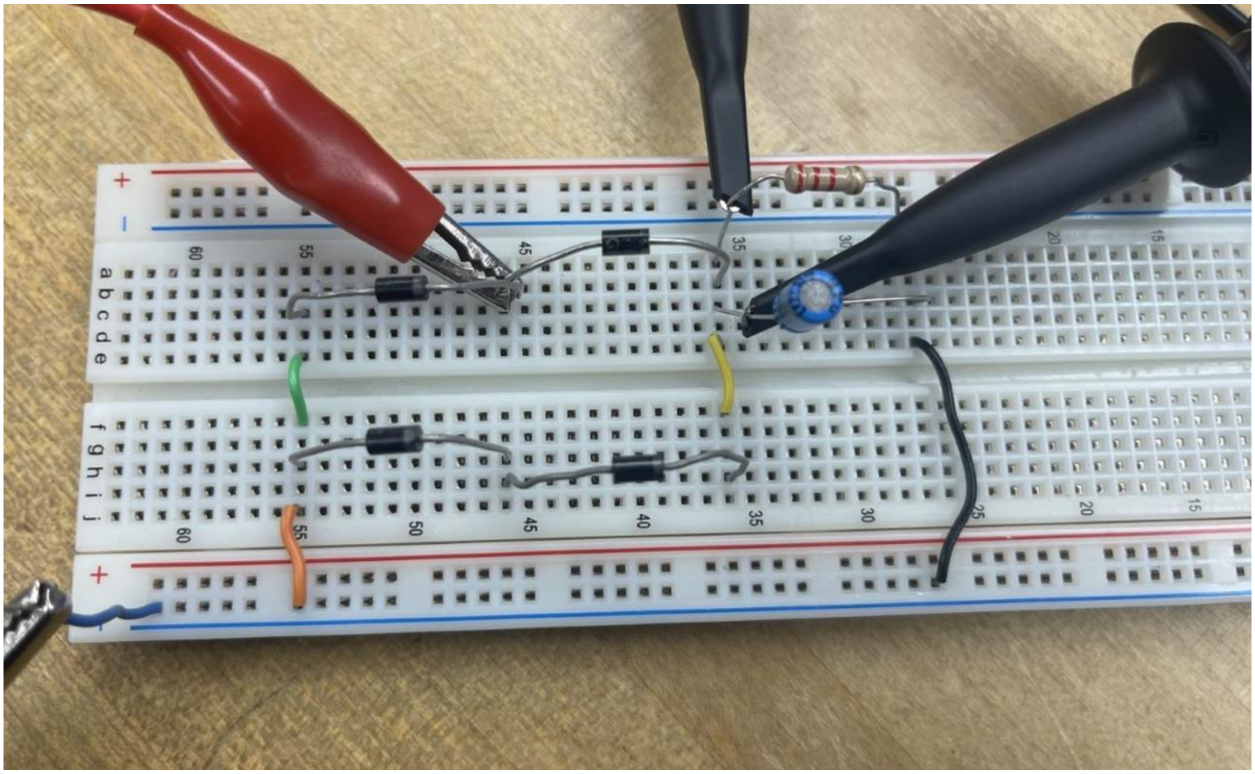
It flattens out more, this is due to the time constant being larger than the period



(Figure 10) Full-Wave Rectifier with Cap Multisim

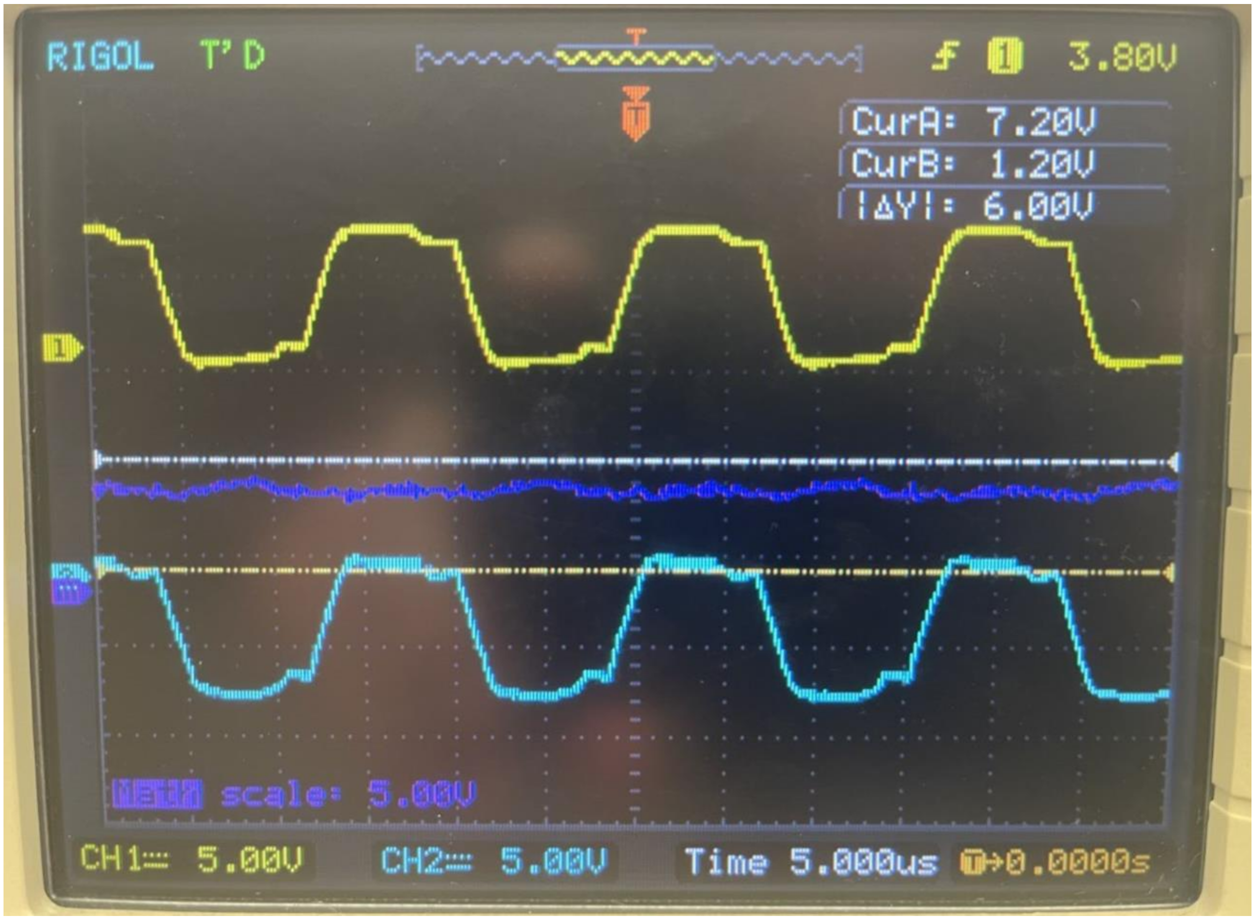


(Figure 11) Full-Wave Rectifier with Cap Agilent Oscilloscope Multisim



*(Figure 12) Full-Wave Rectifier with Cap on the Bench **Channel 2 Probe was placed in the proper location after photo***

(Figure 13) Full-Wave Rectifier with Cap Oscilloscope Bench



(Figure 14) Full-Wave Rectifier with Cap at 60KHz Oscilloscope Bench

Period

$$T = \frac{1}{f} = \frac{1}{1000}$$

$$T = 1\ ms$$

Time Constant (Tau)

$$\tau = RC$$

$$\tau = 2200 * .22 * 10^{-6} = .484\ ms$$

Throughout these experiments, the behavior of the circuits and the resulting data trends provided empirical evidence supporting the theoretical principles of diode rectification and filtering in power supply circuits. Any discrepancies were minor and could be attributed to practical considerations such as component tolerances and measurement accuracy, which are expected aspects of physical circuit construction.

Conclusion:

The primary objectives of this lab were to understand the functionality of diodes in half-wave and full-wave rectification and to observe the effect of filtering on rectified signals. These objectives were successfully met through the construction and analysis of the circuits, where the theoretical concepts were vividly demonstrated by empirical evidence. We learned that diodes indeed permit current to flow in only one direction, effectively converting AC to DC as predicted by semiconductor theory.

The full-wave rectifier's capability to utilize both halves of the AC signal was confirmed, yielding a DC output with a higher average value compared to the half-wave rectifier. Furthermore, the introduction of a filter capacitor illustrated the practical application of a smoothing technique to minimize ripple voltage, which is crucial in power supply design. This lab reinforced our understanding of rectification and filtering, providing a solid foundation for designing and analyzing electronic power systems. There were discrepancies between theoretical calculations and actual measurements which can be attributed to real-world imperfections, but these variances were invaluable learning moments that highlighted the importance of accounting for component tolerances and practical limitations in circuit design.