Pedro Cabrera

Experiment 3

Diode Applications

Diode Limiting and Clamping Circuits

Introduction:

The primary goal of this laboratory exercise is to explore the fundamental characteristics and behaviors of diodes in electronic circuits, focusing specifically on their applications in limiting and clamping configurations. By conducting this experiment, we aim to understand how diodes can be used to alter the shape of an input voltage signal, thereby limiting or modifying its amplitude. This knowledge is crucial as it forms the basis for more complex electronic systems and has practical applications in signal processing. Through hands-on experimentation, we will investigate the theory of semiconductor diodes and observe their behavior in response to a sinusoidal input signal. The expected outcome is to gain a deeper comprehension of the diode's limiting effect on the positive and negative cycles of an AC signal and how a clamping circuit can shift the signal's DC level. This practical approach will allow us to bridge the gap between theoretical electronic principles discussed in lecture presentations and the real-world behavior of electronic components.

Bench Parts and Equipment List:

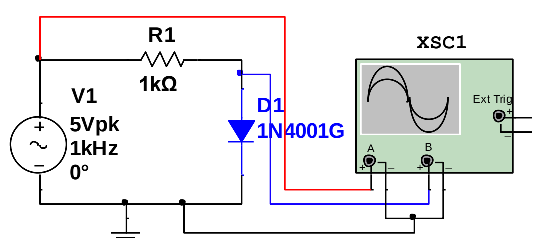
1. **Components Used:**
    - Resistors: 1kΩ
    - Capacitors: 1μF
    - Diodes: 1N4001 (x2)
    - Function Generator
2. **Equipment Used:**
    - Oscilloscope
    - Breadboard
    - Jumper wires

Discussion:

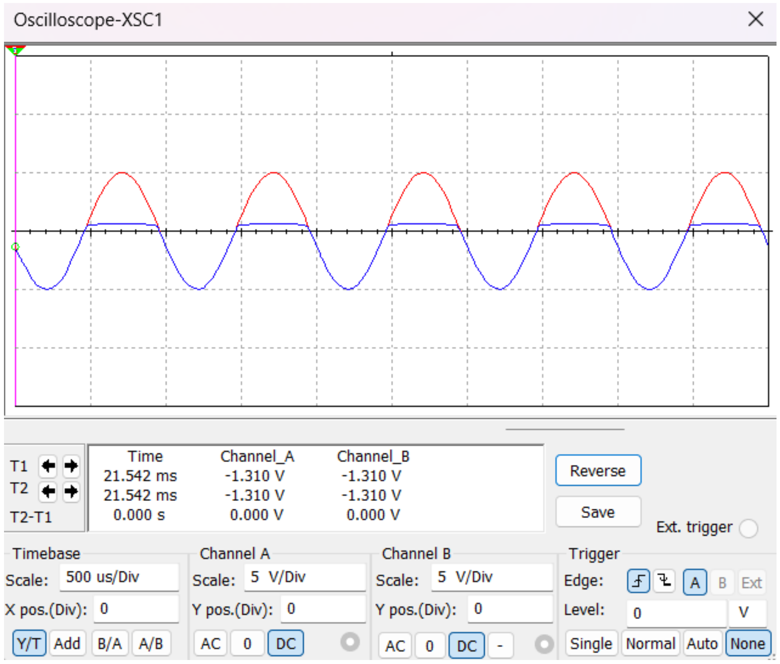
Part 1: Single Diode Limiting Circuit

In the single diode limiting circuit, the data from both the simulation and the physical bench test showed that the diode effectively limited the positive portion of the AC signal. The output waveform had its peaks clipped at approximately 0.7 volts above the reference line, corresponding to the forward voltage drop of the 1N4001 diode. This supported the theory that diodes only allow current to flow above a certain threshold voltage, which in this case is the forward voltage of the diode.

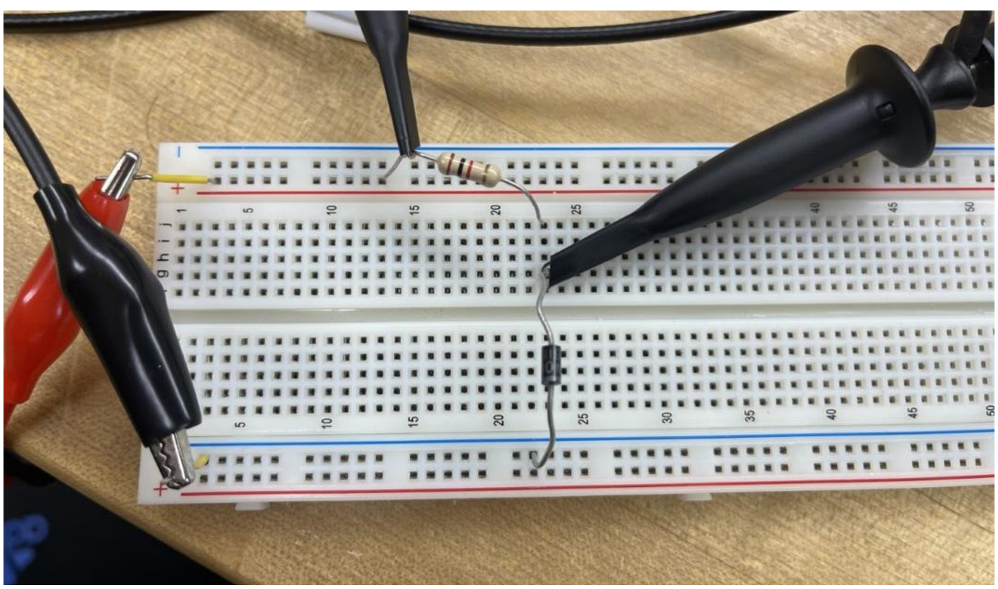
The single diode limiting circuit was first constructed in Multisim, where the virtual oscilloscope displayed a waveform with its positive peaks clipped. Upon replicating the circuit on the bench, the physical oscilloscope confirmed these results. The consistency between simulation and physical testing underlines the accuracy of Multisim as a predictive tool for circuit behavior, particularly the diode's voltage threshold in limiting the amplitude of an AC signal.



(Figure 1) Diode Limiting Circuit with 1N4001G Diode



(Figure 2) Oscilloscope Trace Showing Input and Clipped Output Waveforms from a Diode Limiting Circuit.



(Figure 3) Breadboard Setup of a Diode Limiting Circuit with Test Leads Connected for Measurement.

(Figure 4) Oscilloscope Display of AC Input Signal (Top Trace) and the Corresponding Clamped Output Signal (Bottom Trace).

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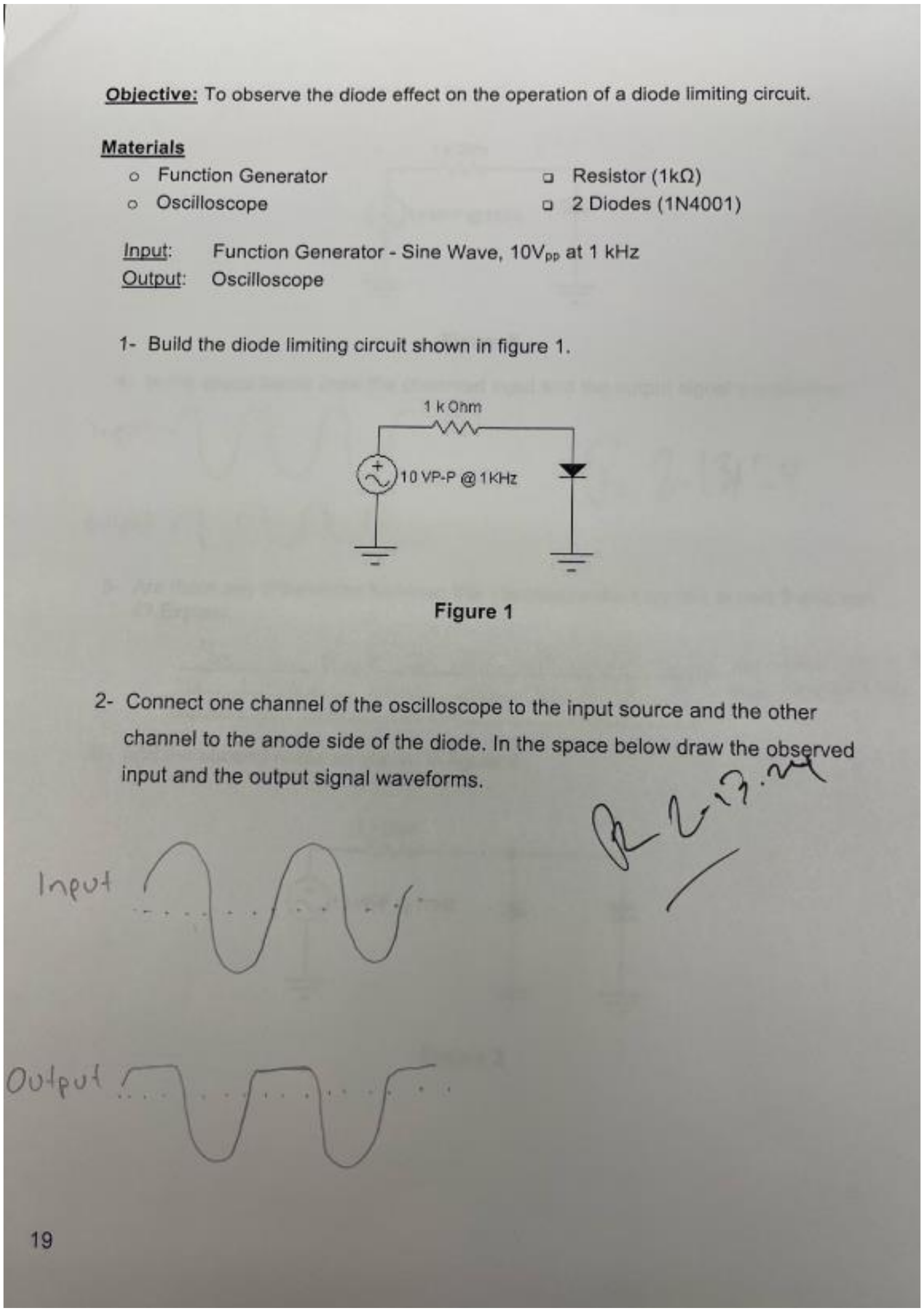

Objective: To observe the diode effect on the operation of a diode limiting circuit.

Materials

- Function Generator
- Oscilloscope
- Resistor (1kΩ)
- 2 Diodes (1N4001)

Input: Function Generator - Sine Wave, $10V_{pp}$ at 1 kHz
Output: Oscilloscope

1- Build the diode limiting circuit shown in figure 1.

Figure 1

2- Connect one channel of the oscilloscope to the input source and the other channel to the anode side of the diode. In the space below draw the observed input and the output signal waveforms.

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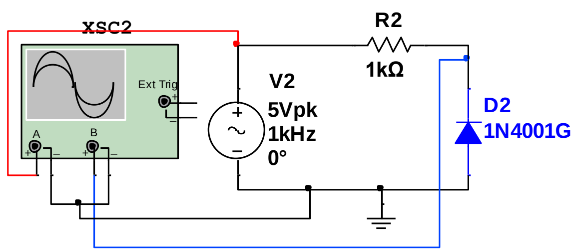
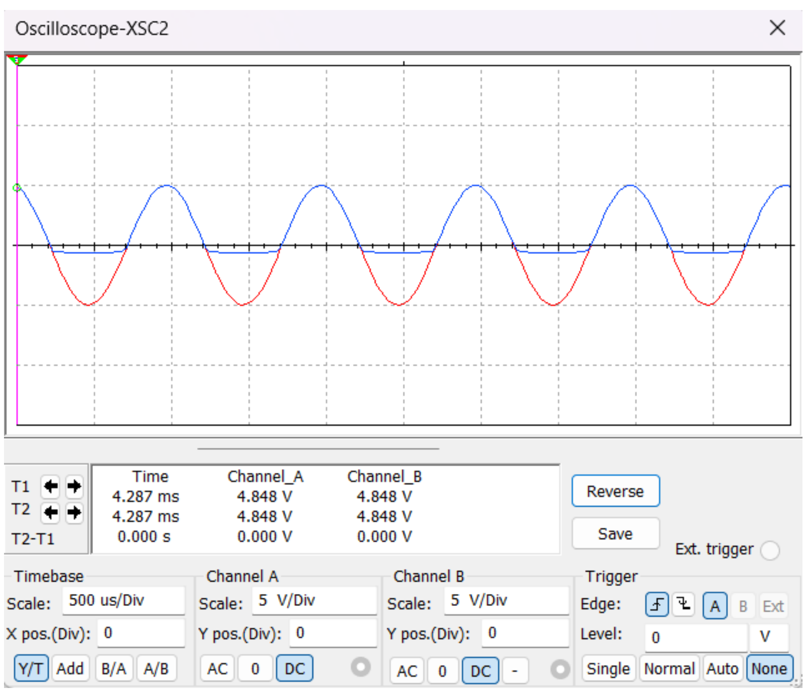
Part 2: Inverted Diode Limiting Circuit

When the diode was rearranged to the inverted position, the negative portion of the AC signal was clipped, as observed on the oscilloscope. This inverse arrangement caused the diode to conduct during the negative half-cycles of the input waveform, limiting the signal in the opposite manner compared to the first circuit. This behavior was in line with the diode's unidirectional current flow property, confirming the theoretical expectations of such a configuration.

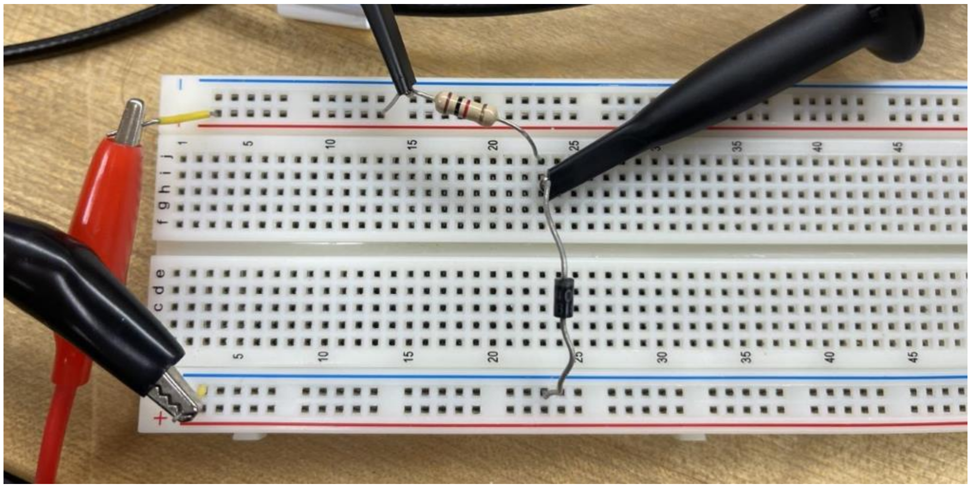
When the diode was positioned to face the opposite direction in both Multisim and the physical setup, the oscilloscope readings showed the negative peaks being limited. The symmetry between the Multisim data and the hands-on results reinforced the understanding that a diode's orientation is crucial in determining the direction of signal limitation, adhering to the principle of unidirectional current flow.



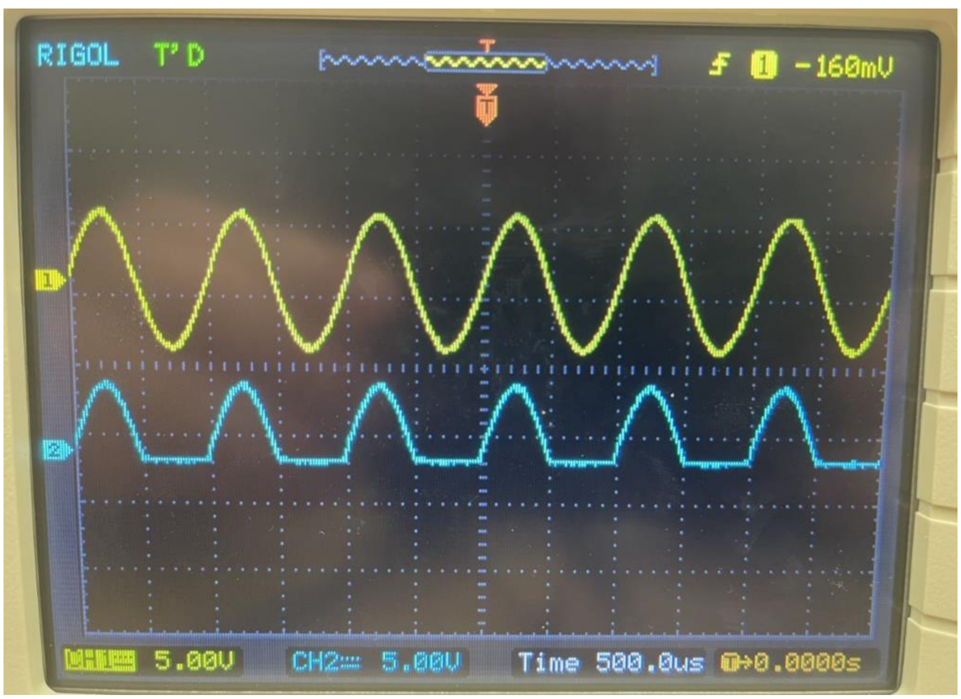
(Figure 5) Inverted Diode Limiting Circuit Multisim.



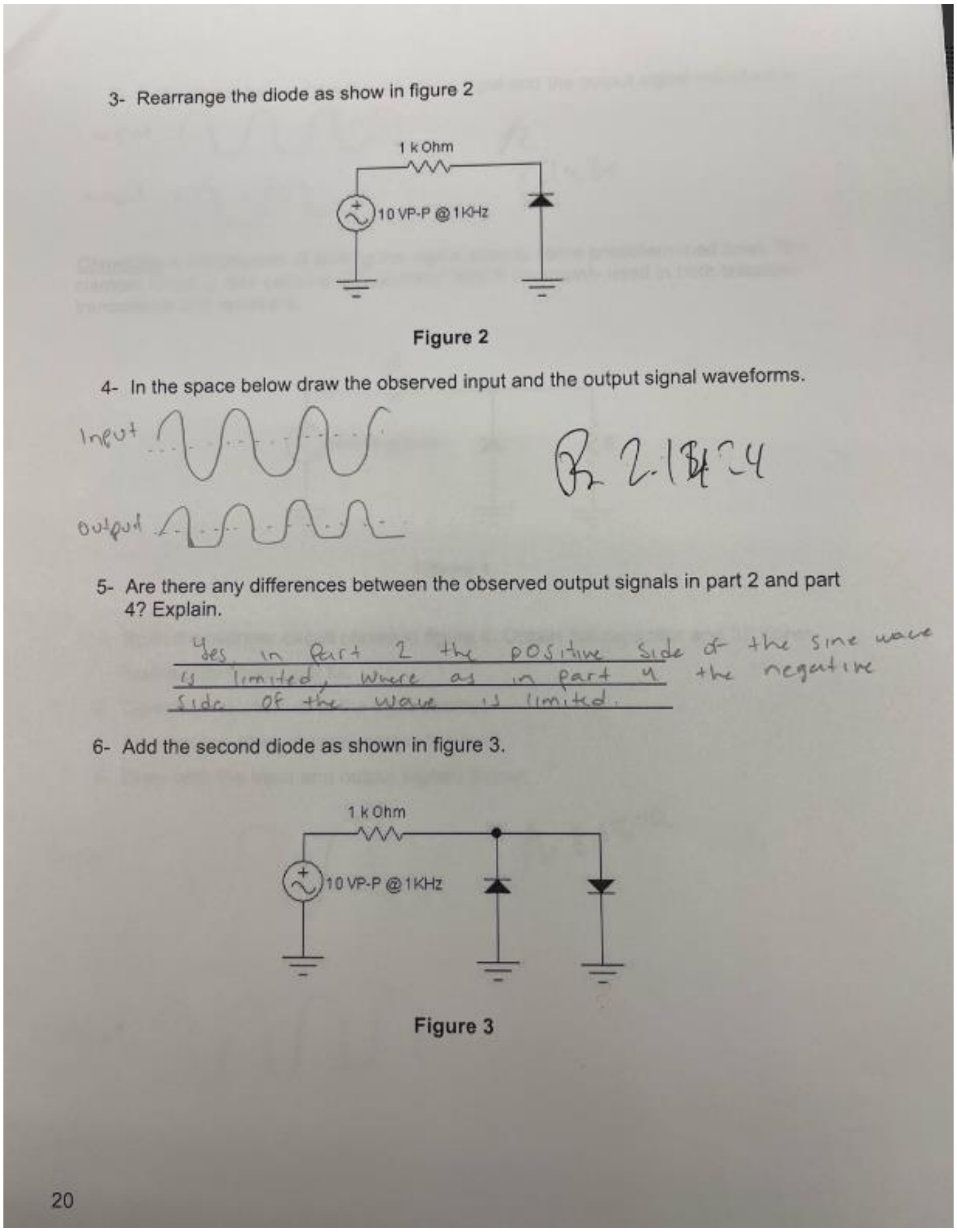
(Figure 6) Oscilloscope Screenshot of a Diode Clamping Circuit.



(Figure 7) Inverted Diode Limiting Circuit (bench).



(Figure 8) Bench Oscilloscope negative clamping.



3- Rearrange the diode as show in figure 2

Figure 2

4- In the space below draw the observed input and the output signal waveforms.

5- Are there any differences between the observed output signals in part 2 and part 4? Explain.

Yes in part 2 the positive side of the sine wave is limited, where as in part 4 the negative side of the wave is limited.

6- Add the second diode as shown in figure 3.

Figure 3

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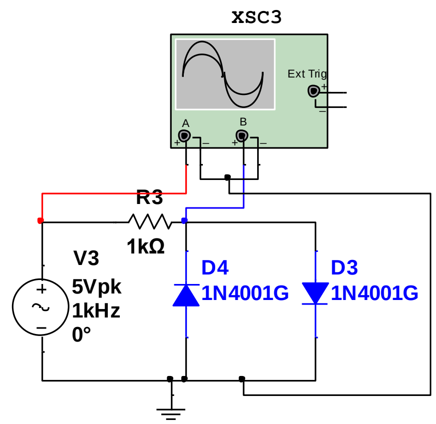
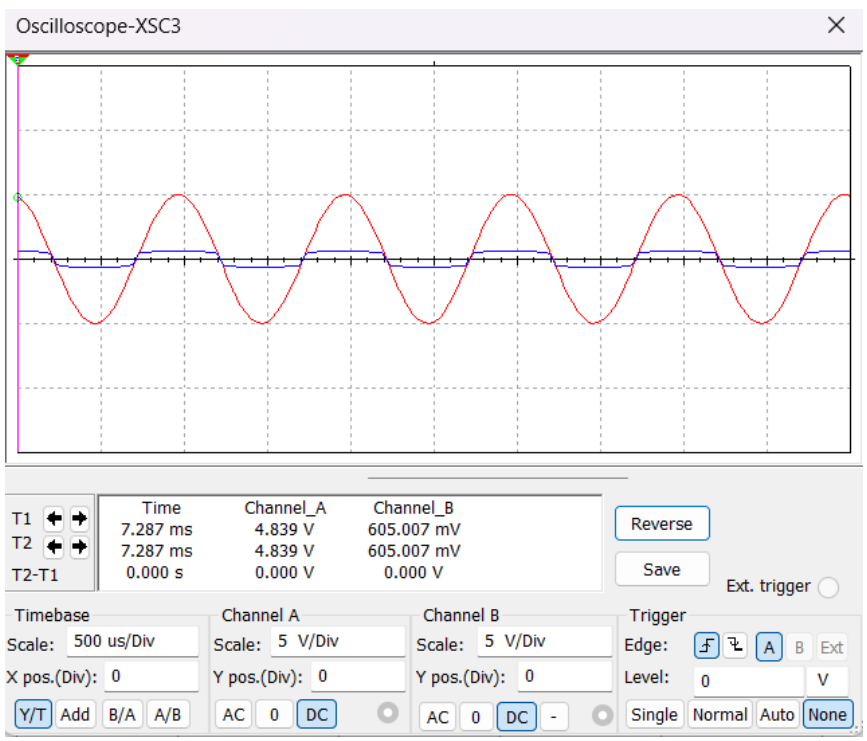
Part 3: Double Diode Limiting Circuit The addition of a second diode in the opposite orientation to the first created a double diode limiting circuit. The resulting data indicated that both the positive and negative peaks of the waveform were clipped. This dual-action confirmed the diode's ability to control signal amplitude in both directions, effectively limiting the entire waveform within a specific voltage range set by the diodes' forward voltage drops.

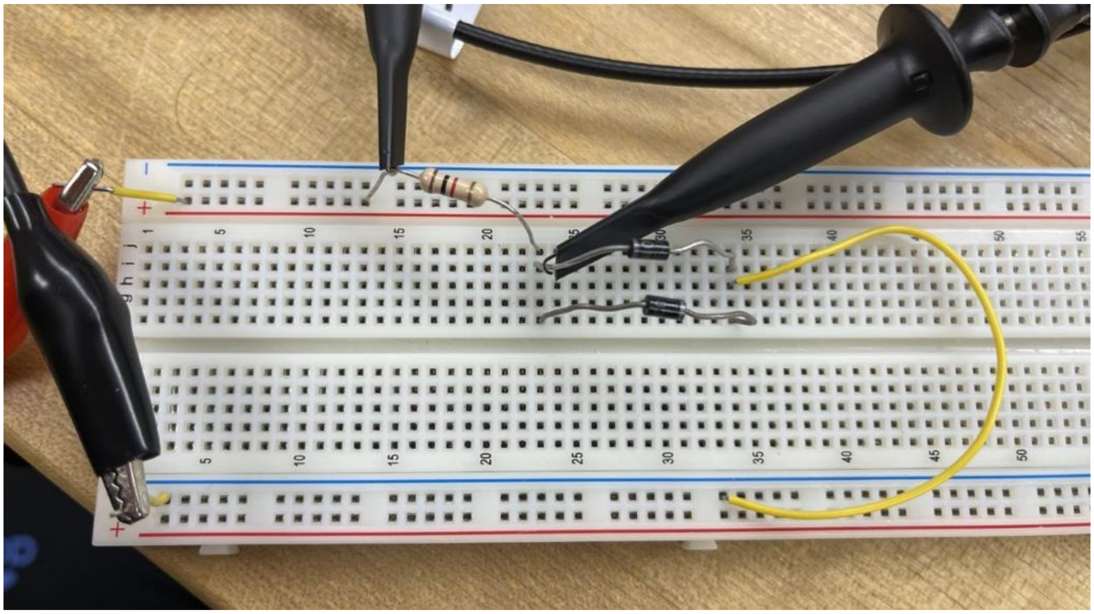
Introducing a second diode in Multisim allowed for the observation of both positive and negative signal clipping, which was successfully duplicated on the bench. This double diode configuration exemplified how diodes can be used in tandem to limit an entire waveform within a set voltage window, verifying the concept of bidirectional limiting through simulation and practical verification.



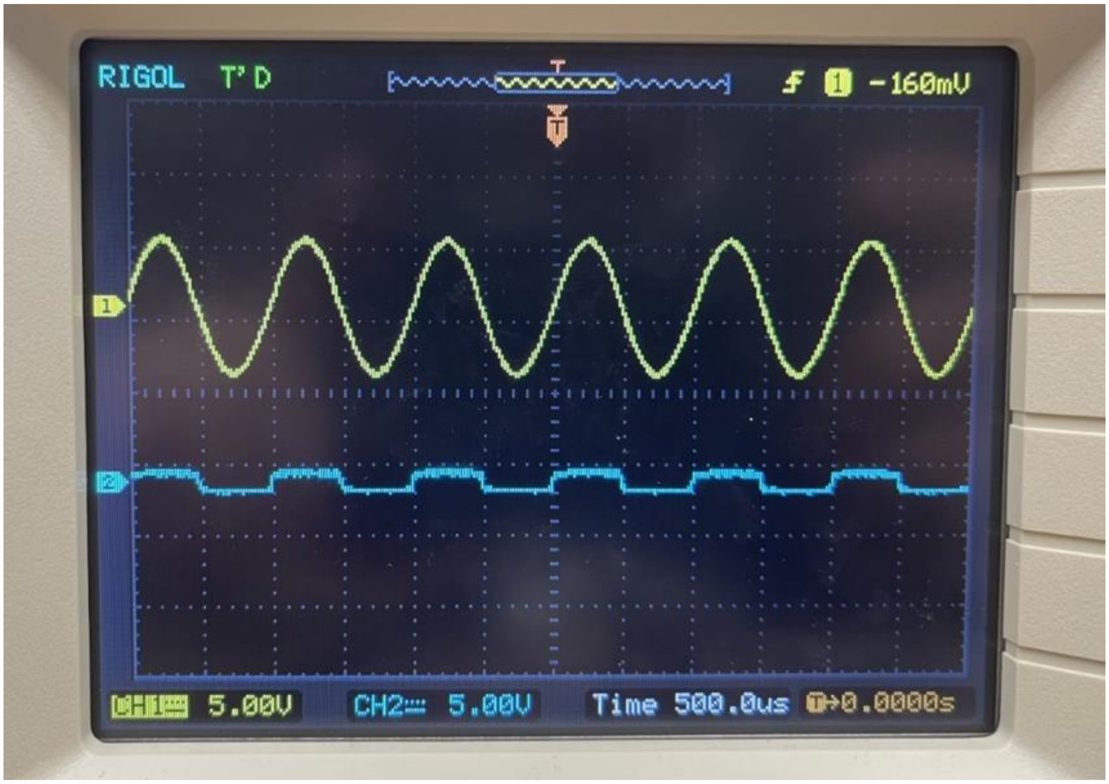
(Figure 9) Double limiting circuit Multisim.



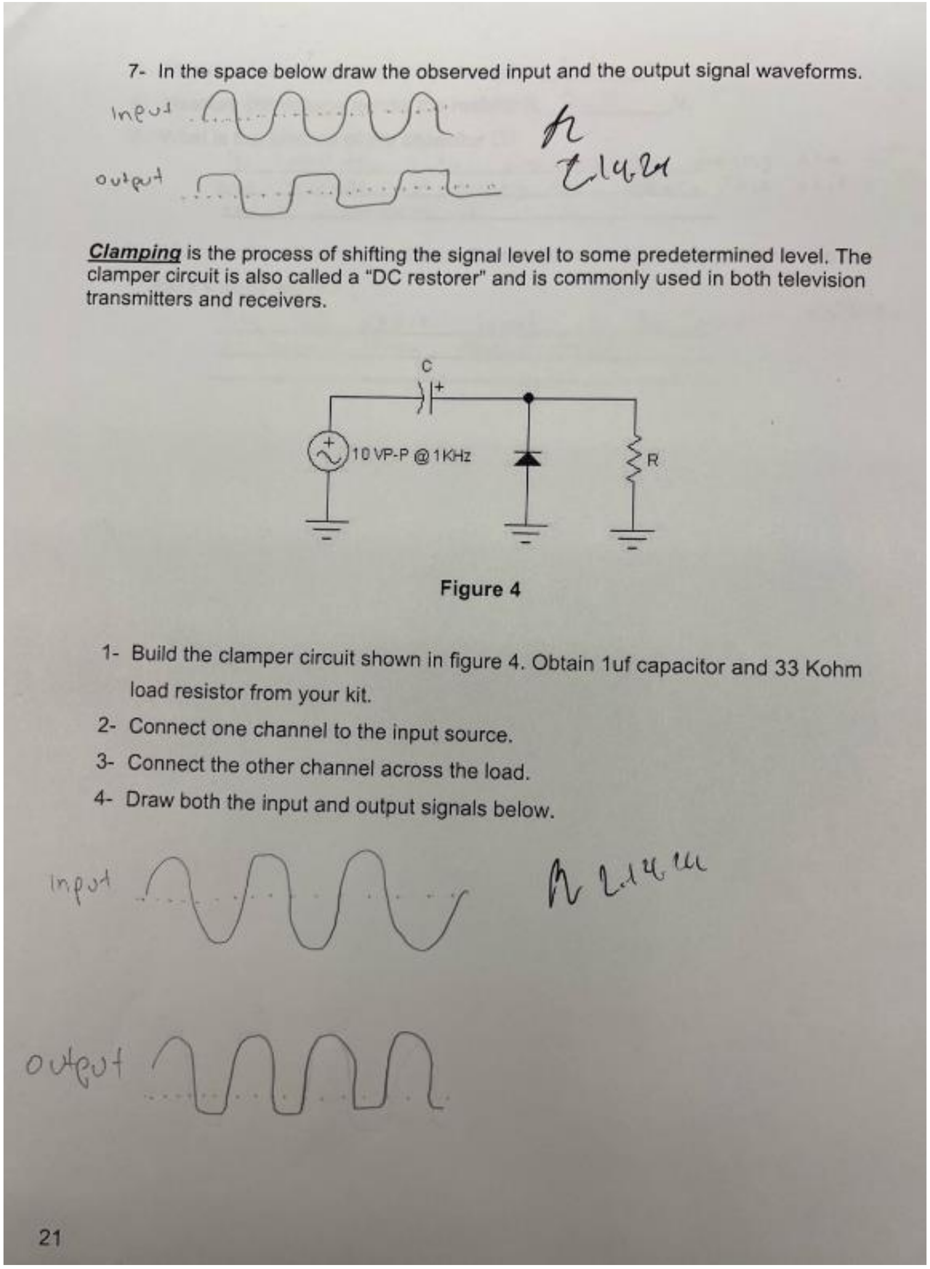
(Figure 10) Oscilloscope input and output waveforms.



(Figure 11) Double Diode limiting circuit Bench.



(Figure12) Oscilloscope bench.



7- In the space below draw the observed input and the output signal waveforms.

input

output

Clamping is the process of shifting the signal level to some predetermined level. The clamper circuit is also called a "DC restorer" and is commonly used in both television transmitters and receivers.

Figure 4

1- Build the clamper circuit shown in figure 4. Obtain 1uf capacitor and 33 Kohm load resistor from your kit.
2- Connect one channel to the input source.
3- Connect the other channel across the load.
4- Draw both the input and output signals below.

input

output

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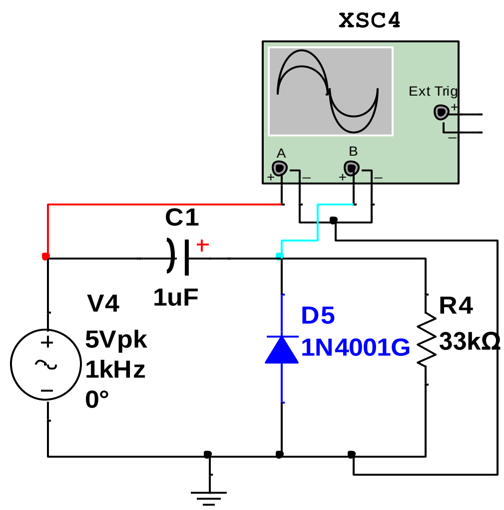
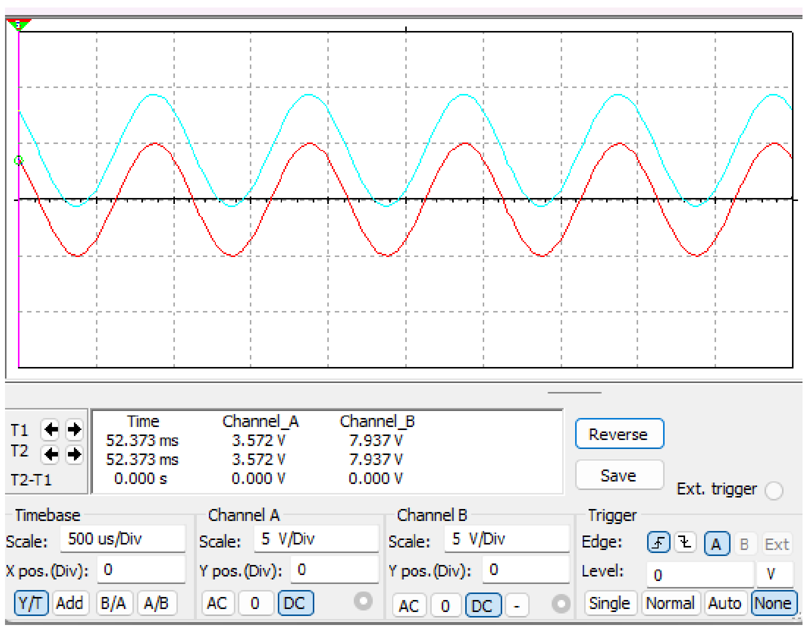
Part 4: Diode Clamping Circuit The diode clamping circuit shifted the entire AC waveform along the voltage axis. The capacitor in the circuit charged to the peak voltage of the waveform during one half-cycle and discharged during the other, moving the waveform up or down in voltage without altering its shape. This effect was evident from the data and demonstrated the clamping action of the circuit. It confirmed the theoretical principle of clamping, where the capacitor and diode work together to 'clamp' the signal to a new DC level.

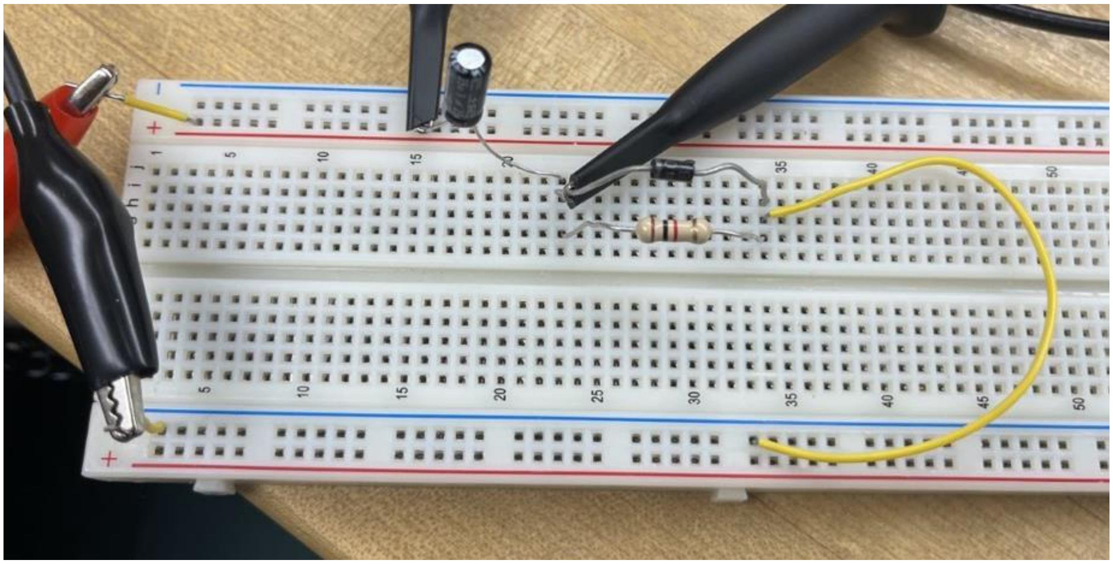
The clamping circuit's behavior in Multisim provided a clear visualization of the DC level shift, which was replicated with actual components. The role of the capacitor in storing and releasing charge, thereby shifting the waveform, was observable in both scenarios. This offered a tangible understanding of the clamping process and the impact of component values on the resultant waveform, highlighting the practical use of simulation software like Multisim to predict real-world circuit operation.



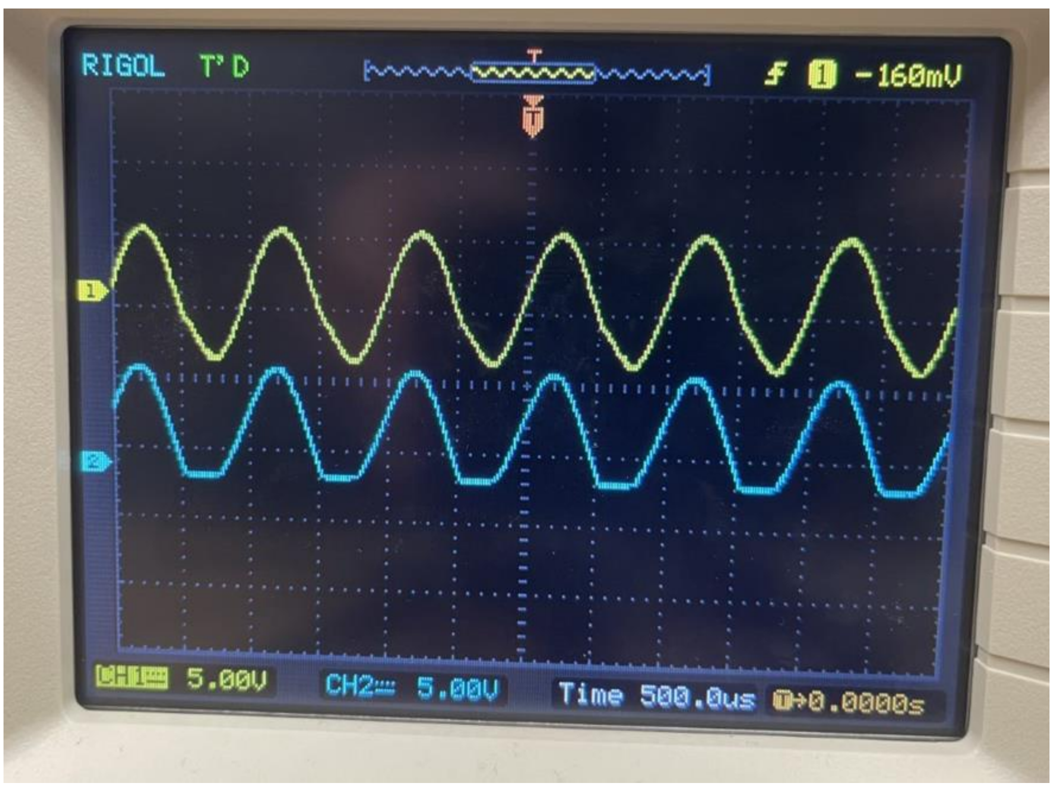
(Figure 13) Multisim DC restorer.



(Figure 14) Oscilloscope input and output waveform Multisim.



(Figure 15) Bench Diode DC restorer.



(Figure 16) Oscilloscope Input and shifted output waveform.

5- Measure the voltage across the capacitor 1.1 V.

6- Measure the voltage across the resistor R 2.9 V.

7- What is the function of the capacitor C?

Its function is to store charge during one cycle and release it during the other. This shifts the entire waveform up

8- What are the differences between the measured output voltage signal and the input voltage signal?

The DC output level of the output voltage is higher than the input.

Conclusion:

The objectives of this lab were to understand the behavior of diodes in limiting and clamping circuits and to observe these effects in practice using both simulation (Multisim) and physical components. The lab successfully met its objectives by demonstrating the theoretical principles of diode operation in various configurations and by providing hands-on experience with the equipment. Through the lab exercises, I learned how the orientation and position of a diode within a circuit can drastically alter the waveform of an input signal. The simulations in Multisim closely mirrored the real-world outcomes, reinforcing the reliability of such software in predicting circuit behavior. Additionally, this lab provided valuable insight into how electronic components like diodes can be utilized in practical applications to modify signal characteristics, such as amplitude limitation and DC level shifting. Ultimately, the lab reinforced my understanding of diode functions and their pivotal role in electronic circuits.