Lab 2 Report

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1 Introduction

In this lab we will be simulating and measuring voltages of various rectifier circuits featuring diodes. We'll be learning about the purposes of rectifier circuits, and we'll be analyzing the features of their output. The three circuits that we are analyzing are shown in Figures 1, 2, and 3. We will simulate and analyze each circuit under two conditions to better understand the functions of each circuit.

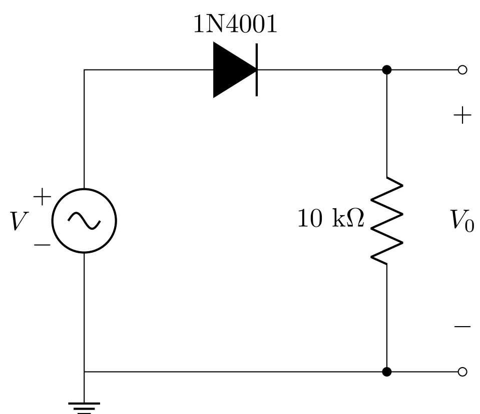

Figure 1: Half-wave Rectifier

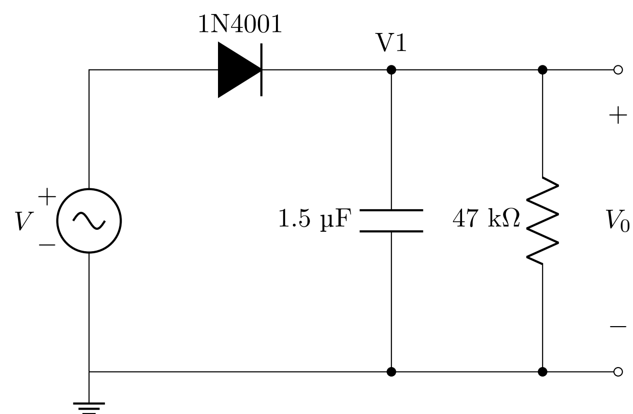

Figure 2: Peak Rectifier Circuit

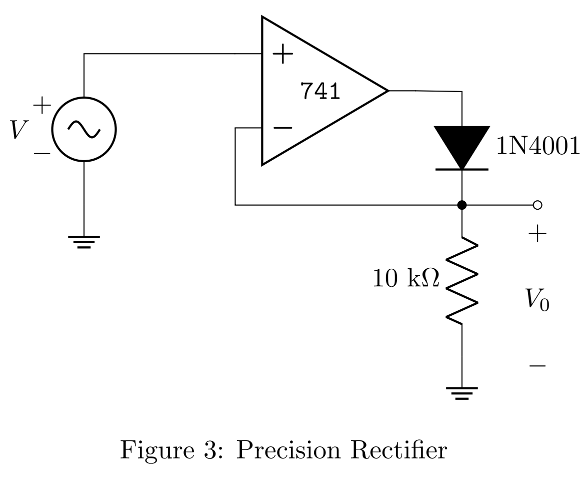

Figure 3: Precision Rectifier

In this report there will be a separate section for each type of rectifier in which we'll analyze the built circuit and measurements taken, as well as the computer analysis done in Multisim.

2 Half-wave Rectifier

The first circuit, shown by Figure 1, is a half-wave rectifier. The diode is preventing current from flowing towards the voltage supply, and therefore will only allow a positive voltage over V_0. The result is an output waveform that returns only the positive voltage from the input. With an input sinusoidal voltage of 10 V$_{pk-pk}$, we measure an output half-sine wave that is decreased just slightly because of the operating voltage of the diode. In Figure 4 you can see that the peak voltage of the output signal is 9.4 V when 10 V input was used, a decrease of about 0.6 V. This follows closely with the analysis provided by the constant drop model, which says that a drop of about 0.7 V occurs across a forward biased diode. The output voltage minimum sits at 0 V.

In Figure 4 we can see that the half-wave rectifier showed very poor performance for a low input sinusoidal signal. The output was just a small bump, and only rose above 0 V for a small portion of the positive range of input voltage. The minimum was 0 V, and the maximum was 113 mV.

Compare these results with those from the simulation as captured in Figure 5.

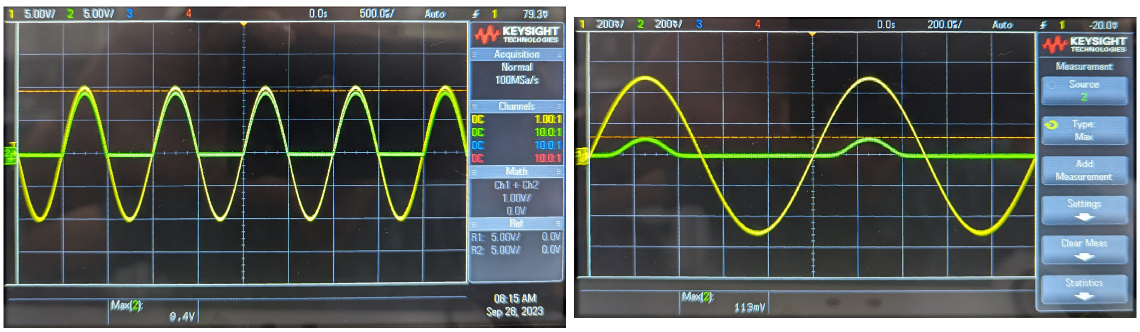

Figure 4: Half-wave Rectifier Results - Left: 10 V$_{pk}$ Input - Right: 0.5 V$_{pk}$ Input

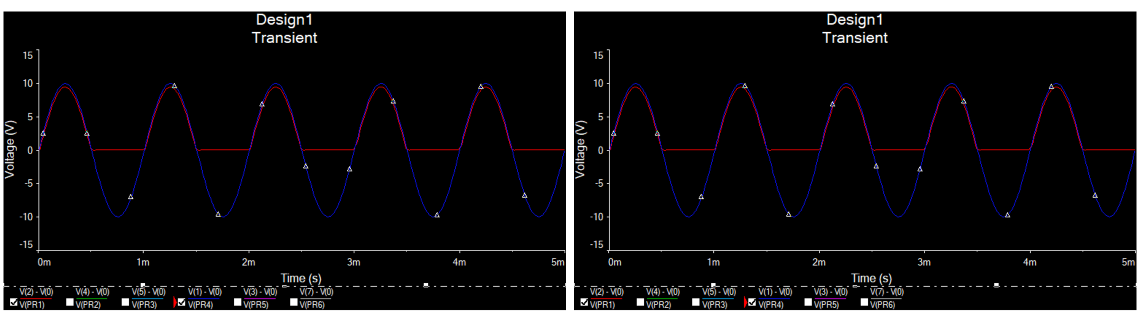

Figure 5: Half-wave Rectifier Simulation - Left: 10 V$_{pk}$ Input - Right: 0.5 V$_{pk}$ Input

3 Peak Rectifier

Looking at Figure 6 we can see the performance of the peak rectifier with two different resistor values being placed in parallel with the capacitor. The capacitor allows the voltage to remain high when the sinusoidal input voltage dips below its peak. When a higher resistance was placed in parallel with the capacitor the high output signal was maintained much better than with a lower value resistor. In both cases an input signal of 10 V$_{pk}$ was used. You can see that the peak-to-peak voltage when the 47 kΩ resistor was used was about half the peak-to-peak range compared to when the 4.7 kΩ resistor was used.

Compare our measured results with the simulated ones as found in Figure 7.

Figure 6: Peak Rectifier Results - Left: 47 kΩ Resistor - Right: 4.7 kΩ Resistor

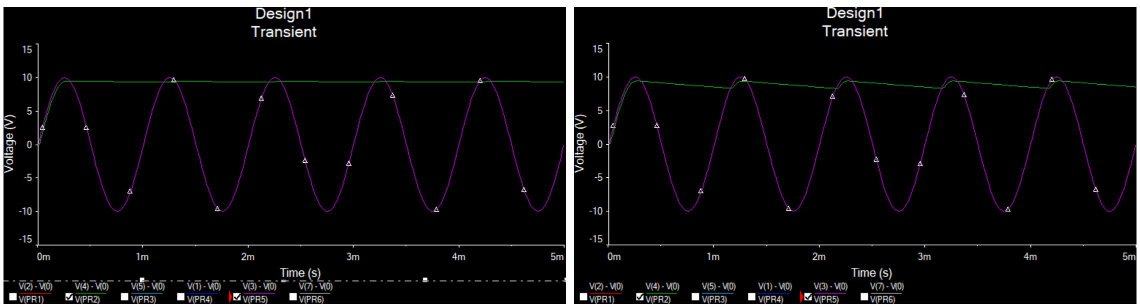

Figure 7: Peak Rectifier Simulation - Left: 47 kΩ Resistor - Right: 4.7 kΩ Resistor

4 Precision Rectifier

The precision rectifier shown in Figure 3 utilizes an operational amplifier to accomplish the same task as the circuit in Figure 1, but it does the jump better. The configuration ensures that the output voltage stays as close to the input voltage when the input is positive, and it remains at 0 V when the input is negative. You can see from the results in Figure 8 and the simulation in Figure 9 that the precision rectifier does a much better job at keeping the output voltage much closer to the value of the input voltage when it is being passed through. Here there is no 0.7 V drop that usually occurs with the use of the diode, even at a low input signal of just 500 mV.

Figure 8: Precision Rectifier Results - Left: 10 V_{pk} - Right: 0.5 v_{pk}

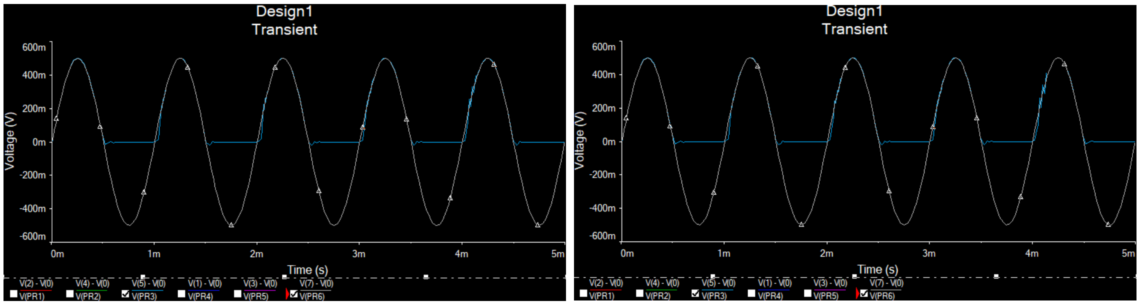

Figure 9: Precision Rectifier Simulation - Left: 10 V_{pk} - Right: 0.5 v_{pk}

5 Post-measurement Exercise

See the table in Figure 10 for our resistor values.

Circuit	**Target Value**	**Measured Value**
1	10 kΩ	10.018 kΩ
2	47 kΩ	46.24 kΩ
2	4.7 kΩ	4.604 kΩ
3	10 kΩ	10.018 kΩ

Figure 10: Measured Resistor Values

Images of the simulated circuits are omitted for brevity, and because they appear the same as the simulations that were done with precise resistor values.

6 Summary

One of the most important uses of semiconductor devices is the process of rectification. This allows us to take an alternating voltage or current input and translate it to direct voltage or current with little loss in energy. Simple rectifiers such as the one in Figures 1 and 2 illustrate that decent results can be achieved in the right conditions with very few components. However, a simple operational amplifier can take things to the next level.