Lab 2 - Rectifier Circuits

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1 Introduction

In this lab we are analyzing the performance of three different rectifier circuits, namely a half-wave rectifier, a peak rectifier, and a precision rectifier. For each circuit shown we will simulate the circuit, then build and measure what we simulated to compare.

This lab is going to have a lot of figures and tables.

2 Half-wave Rectifier

The half-wave rectifier, as shown in Fig. 1, is a circuit that cuts out the negative portion of an AC wave. With an ideal diode, we would be able to get a perfect positive-portion of an AC wave without any power loss, but because the diodes show a voltage drop when forward-biased, the output is always a touch lower than the input. Refer to Fig. 2 to see the slight decrease on the output. Measured values are shown in Table 1.

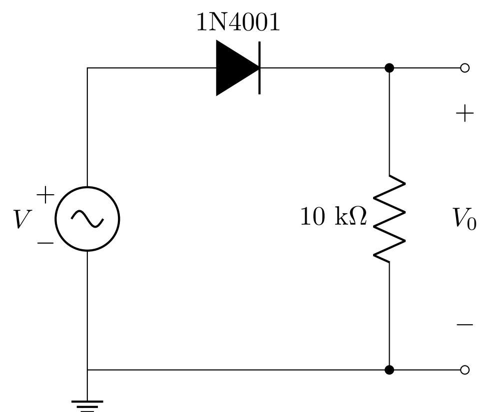

Figure 1: Half-wave Rectifier Circuit

	10 V_{pp}			0.5 V_{pp}		
	Simulated	Simulated 9.74 kΩ	Measured	Simulated	Simulated 9.74 kΩ	Measured
V_{MAX}	4.503	4.502	4.502	0.025	0.024	0.003
V_{MIN}	-0.011	-0.010	-0.080	-0.001	-0.001	-0.001
V_{pp}	4.513	4.612	4.583	0.025	0.025	-0.004

Table 1: Half Wave Rectifier Simulation and Measurement Values

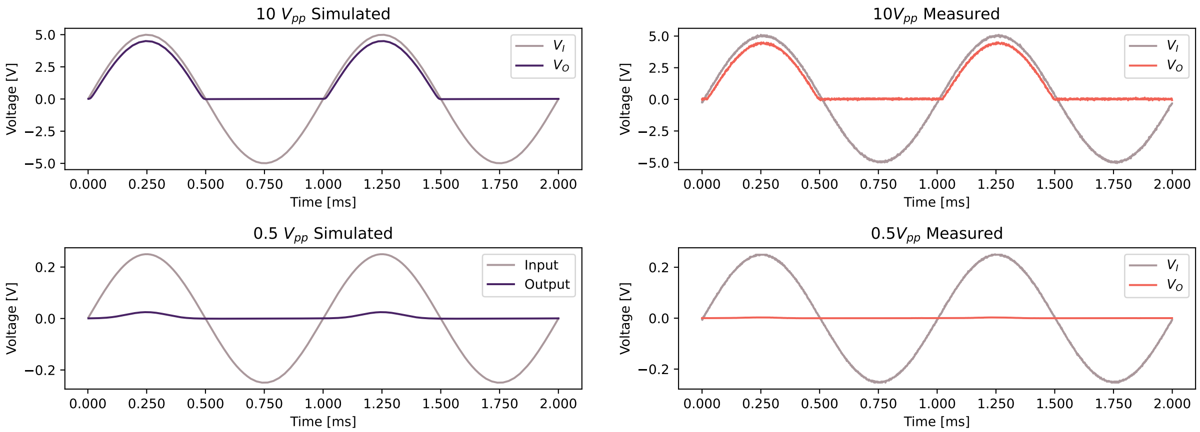

Figure 2: Half-wave Rectifier Circuit Plots

3 Peak Rectifier

The peak rectifier is very similar to the half-wave rectifier, but it utilizes a capacitor in parallel with the output to maintain a high voltage on the output. This effectively converts an AC signal to DC, and can be clearly seen in Fig. 4. Measured values are captured in Table 2.

Choosing an appropriate resistor to show the output is important if the electronics connected to the output are sensitive to small changes in DC power. The output shows a small ripple voltage (which can also be seen in Table 2). If the goal is to keep a small ripple voltage, the correct capacitor/resistor combination will be desired to keep the decay to a minimum during the negative portion of the input sine wave.

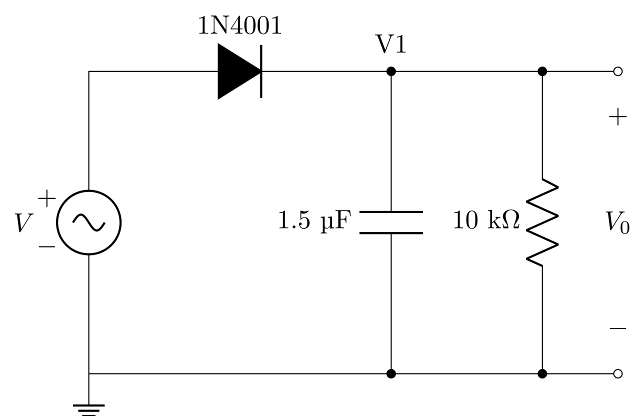

Figure 3: Peak Rectifier Circuit

	47 kΩ			4.7 kΩ		
	Simulated	Simulated 44.8 kΩ	Measured	Simulated	Simulated 4.607 kΩ	Measured
V_{MAX}	4.453	4.452	4.342	4.419	4.418	4.020
V_{MIN}	4.392	4.388	4.020	3.898	3.888	3.377
Ripple	0.025	0.063	0.322	0.521	0.531	0.643

Table 2: Peak Rectifier Simulation and Measurement Values

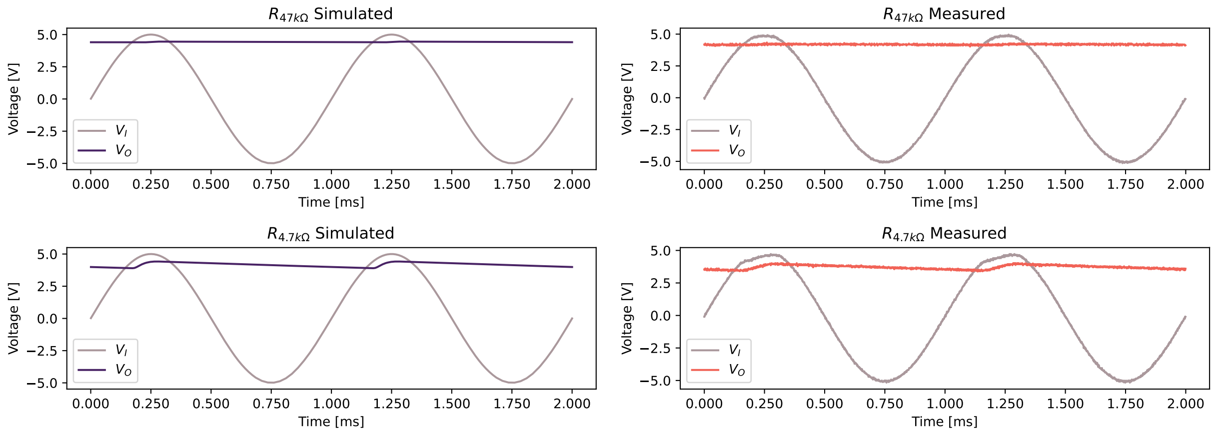

Figure 4: Peak Rectifier Circuit Plots

4 Precision Rectifier

The precision rectifier is a circuit which utilizes an op amp to effectively operate like an ideal diode and remove the voltage drop on the positive side that occurred with the half-wave rectifier circuit. The result is an almost perfect half-sine, but when the voltage is near zero there is some distortion. It is even more prevalent when the amplitude of the input voltage is low. This is seen if Fig. 6, and the values from the measurements and simulation are shown in Table 3.

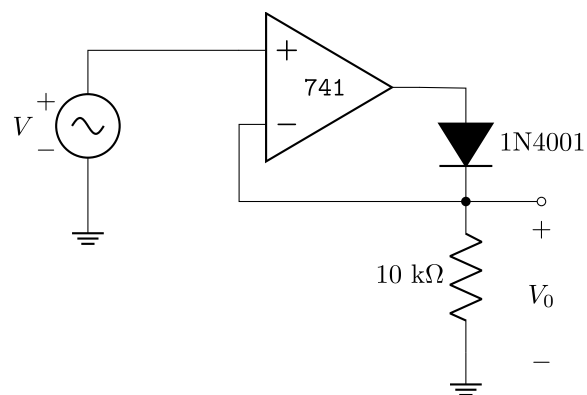

Figure 5: Precision Rectifier Circuit

	10 V_{pp}			0.5 V_{pp}		
	Simulated	Simulated 9.74 kΩ	Measured	Simulated	Simulated 9.74 kΩ	Measured
V_{MAX}	4.991	4.993	5.025	0.250	0.250	0.249
V_{MIN}	-0.010	-0.010	-0.352	-0.032	-0.031	-0.024
V_{pp}	5.091	5.090	5.377	0.282	0.281	0.273

Table 3: Precision Rectifier Simulation and Measurement Values

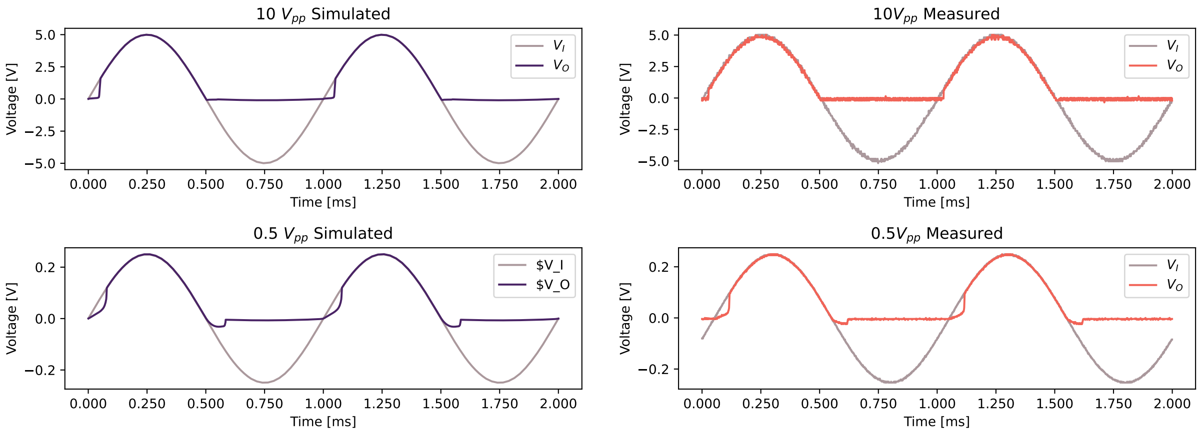

Figure 6: Precision Rectifier Circuit Plots

5 Conclusion

Our simulations of the rectifier circuits were very similar to the measured outputs that we captured when we built the circuit. I thought the most interesting circuit that we analyzed was the precision rectifier, I wasn't expecting so much distortion on the output. It seemed that the distortion occurred when the diode was no longer forward biased. I wonder if an ideal diode would be the solution to making this a perfect half-sine as well.

I also thought it was interesting that the voltage of the input was affected by the peak rectifier circuit when it was measured. I wasn't able to find a logical conclusion for why that occurred when we were just directly measuring the input from the function generator.