ELEC-313
Lab 3: Diode Circuits

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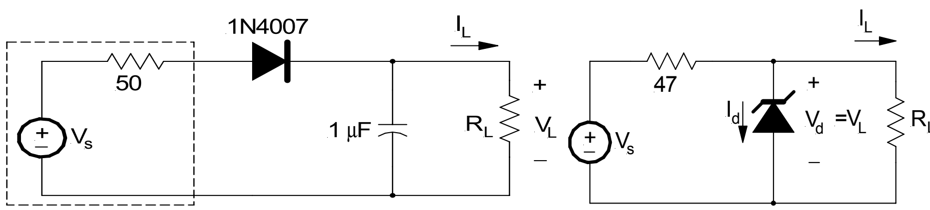
1 Objective

The objective is to construct, measure, and observe the behavior of two common diode circuits: a voltage rectifier, and a voltage regulator.

2 Equipment

Diode: 1N4007
Zener diode: 1N5231
Resistors: 47 Ω
Capacitor: 1 µF
Resistive decade box: HeathKit IN-3117
Power supply: HP E3631A
Function generator: HP 33120A
Multimeter: Fluke 8010A
Oscilloscope: Agilent 54622D

3 Schematics



(a) Voltage rectifier circuit. (b) Voltage regulator circuit.

Figure 1: Circuits used in this lab.

4 Procedure

4.1 Voltage Rectifier

First, the capacitance of a 1 µF capacitor was measured and recorded in Table 1 along with the percent difference calculated (Eq). Then the circuit shown in Figure 1a was constructed on a breadboard. The voltage source (V_S) and 50 Ω resistor seen in Figure 1a represented the function generator used. Using a resistive decade box, the load resistance (R_L) was initially set to 10 kΩ. Then, the first channel of the oscilloscope was set to measure the output of the function generator and the second channel was set to measure the voltage across the load (V_L). The function generator was programmed to produce a sine wave of 1 V_{peak} at 400 Hz, measured with the oscilloscope. V_{max}, V_{min}, and DC voltage across V_L was measured with a multimeter and recorded in Table 2 along with the ripple voltage V_r (Eq 2). Finally, the source voltage was then left at 5 V_{peak}, and R_L was adjusted to 1 kΩ and 100 kΩ and each V_{DC}, V_{max}, V_{min}, and V_r were measured and recorded in Table 3.

4.2 Voltage Regulator

First, a 47 Ω resistor was measured and its % difference from the nominal resistance value was calculated and both values were recorded in Table 4. The circuit shown in Figure 1b was constructed on a breadboard, the HP power supply for the voltage source (V_S) set to 9 V, and a decade resistance box as the load resistance (R_L) set to 1 kΩ. Then the load voltage (V_L) and load current (I_L) was measured and recorded in Table 6, for the R_L of 1 kΩ, 330 Ω, and 100 Ω. The Zener diode was removed and the open-circuit voltage (V_{OC}) was measured and recorded in Table 6, again for the R_L of 1 kΩ, 330 Ω, and 100 Ω. The Zener diode was added back into the circuit and, using the R_L of 1 kΩ, 330 Ω, and 100 Ω, the point at which the source drops out of regulation (V_S drop) was determined and recorded in Table 6 by sweeping the V_S. Finally, the R_L was removed (R_L=∞), V_S was set to 9 V, and the voltage across the Zener diode (also V_L) was measured and recorded in Table 6.

5 Results

Nominal (µF)	Measured (µF)	Difference
1	0.938	6.2%

Table 1: Percent difference of capacitor in rectifier circuit.

V_S (V_{peak})	V_{max} (V)	V_{min} (V)	V_r (V)	V_{DC} (V)	Ripple
1	0.488	0.369	0.119	0.429	24.4%
2	1.41	1.10	0.310	1.26	22.0%
3	2.39	1.88	0.510	2.14	21.3%
4	3.31	2.38	0.930	2.85	28.1%
5	4.25	3.19	1.06	3.72	24.9%

Table 2: AC input vs. DC output of rectifier circuit, where $R_L = 10\,\mathrm{k\Omega}$.

R_L (Ω)	V_{max} (V)	V_{min} (V)	V_r (V)	V_{DC} (V)	Ripple
1k	4.13	0.440	3.69	2.29	89.3%
10k	4.25	3.19	1.06	3.72	24.9%
100k	4.321	4.193	0.128	4.257	2.962%

Table 3: Effect of R_L on DC output in rectifier circuit.

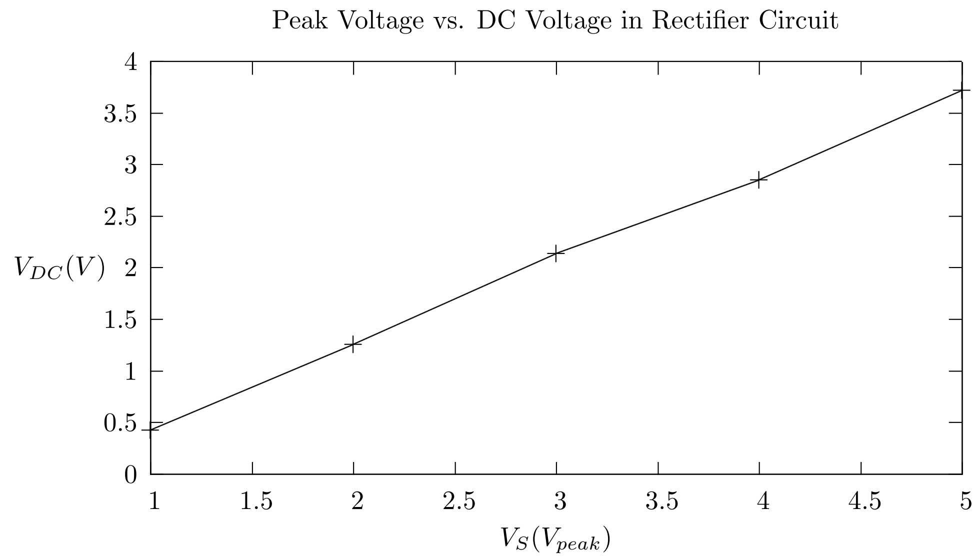


Figure 2: AC input vs. DC output of rectifier circuit, where $R_L = 10\,\mathrm{k}\Omega$

Nominal (Ω)	Measured (Ω)	Difference
47	46.52	1.13%

Table 4: Percent difference of resistor in voltage regulator circuit.

R_L (Ω)	V_{OC} (V)	V_S Drop (V)
100	6.12	7.5
330	7.88	5.8
1k	8.90	5.3

Table 5: Calculated values for voltage regulator circuit

R_L (Ω)	V_L (V)	I_L (mA)	V_{OC} (V)	V_S Drop (V)	Voltage Regulation
100	5.163	50.9	6.10	7.5	5.02%
330	5.318	15.62	7.87	5.9	4.03%
1k	5.11	5.27	8.60	5.3	1.15%
∞	5.38	—	—	—	—

Table 6: Measured values for voltage regulator circuit

R_L (Ω)	V_{OC} (% diff)	V_S Drop (% diff)
100	0.359%	0.0%
330	0.102%	1.7%
1k	3.327%	0.0%

Table 7: Comparison of values for voltage regulator circuit

6 Comparison of Results

The PSpice computed values of V_{OC} shown in Table 5, were very close to the measured V_{OC} values (Table 5), and were at most only 3.327% different (Table 7). Also, the PSpice computed V_S drop (Table 5) was very close to the measured V_S drop (Table 6)and the % difference was at most only 1.7% (Table 7) (suggesting that the experimenter may have peaked at the computed results and subconsciously (or consciously) noticed the recorded value to be almost exactly the same in all three circumstances).

7 Conclusion

As seen in Figure 2, as the peak voltage of the rectifier circuit increases, the rectifier DC voltage increases. Also, as load resistance is increased on the rectifier, it decreases the % ripple as shown in Table 3. This was probably because the increase of resistance reduced the amount of current that could be dissipated from the capacitor over the same amount of time before it was charged up again. Additionally, the % ripple would likely decrease as the input frequency were increased because there would be a smaller time interval for the capacitor to discharge.

As shown in Table 6, the voltage regulation (calculated using Equation 3) across the $100\,\Omega$ resistor is 5.02% different than the 5.38 V measured when the load resistor was removed from the circuit. This shows that the Zener diode used in the experiment is not an ideal Zener. In the regulator circuit (Figure 1b), when V_S is below the Zener diode voltage (V_Z), V_{OC} is linearly related to V_S. When V_S is above V_Z, V_{OC} is almost at a constant value approximately equal to V_Z. When V_S is close to V_Z, the relationship of V_{OC} to V_S is not linearly related and the simplified calculations we learned in class are less effective at computing the V_{OC}.

8 Equations

$$\%_{diff} = \frac{|nominal - measured|}{nominal} \times 100\% \tag{1}$$

$$V_r = V_{max} - V_{min} \tag{2}$$

$$\%_{reg} = \frac{V_{load} - V_{noload}}{V_{noload}} \times 100\% \tag{3}$$