

# 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:  $47\ \Omega$

Capacitor:  $1\ \mu\text{F}$

Resistive decade box: HeathKit IN-3117

Power supply: HP E3631A

Function generator: HP 33120A

Multimeter: Fluke 8010A

Oscilloscope: Agilent 54622D

## 3 Schematics

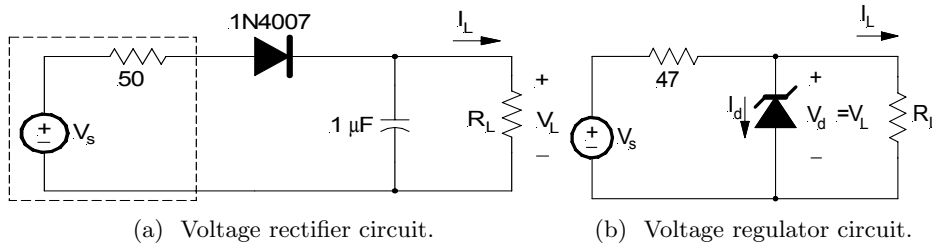


Figure 1: Circuits used in this lab.

## 4 Procedure

### 4.1 Voltage Rectifier

First, the capacitance of a  $1\ \mu\text{F}$  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  $50\ \Omega$  resistor seen in Figure 1a represented the function generator used. Using a resistive decade box, the load resistance ( $R_L$ ) was initially set to  $10\ \text{k}\Omega$ . 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  $1\ \text{V}_{\text{peak}}$  at  $400\ \text{Hz}$ , measured with the oscilloscope.  $V_{\text{max}}$ ,  $V_{\text{min}}$ , 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  $5\ \text{V}_{\text{peak}}$ , and  $R_L$  was adjusted to  $1\ \text{k}\Omega$  and  $100\ \text{k}\Omega$  and each  $V_{\text{DC}}$ ,  $V_{\text{max}}$ ,  $V_{\text{min}}$ , and  $V_r$  were measured and recorded in Table 3.

## 4.2 Voltage Regulator

First, a  $47\ \Omega$  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  $1\text{ k}\Omega$ . Then the load voltage ( $V_L$ ) and load current ( $I_L$ ) was measured and recorded in Table 6, for the  $R_L$  of  $1\text{ k}\Omega$ ,  $330\ \Omega$ , and  $100\ \Omega$ . 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  $1\text{ k}\Omega$ ,  $330\ \Omega$ , and  $100\ \Omega$ . The Zener diode was added back into the circuit and, using the  $R_L$  of  $1\text{ k}\Omega$ ,  $330\ \Omega$ , and  $100\ \Omega$ , 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 ( $R_L=\infty$ ),  $V_S$  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 ( $\mu\text{F}$ )	Measured ( $\mu\text{F}$ )	Difference
1	0.938	6.2%

Table 1: Percent difference of capacitor in rectifier circuit.

$V_S$ ( $V_{\text{peak}}$ )	$V_{\text{max}}$ (V)	$V_{\text{min}}$ (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  $R_L = 10\text{ k}\Omega$ .

$R_L$ ( $\Omega$ )	$V_{\text{max}}$ (V)	$V_{\text{min}}$ (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.

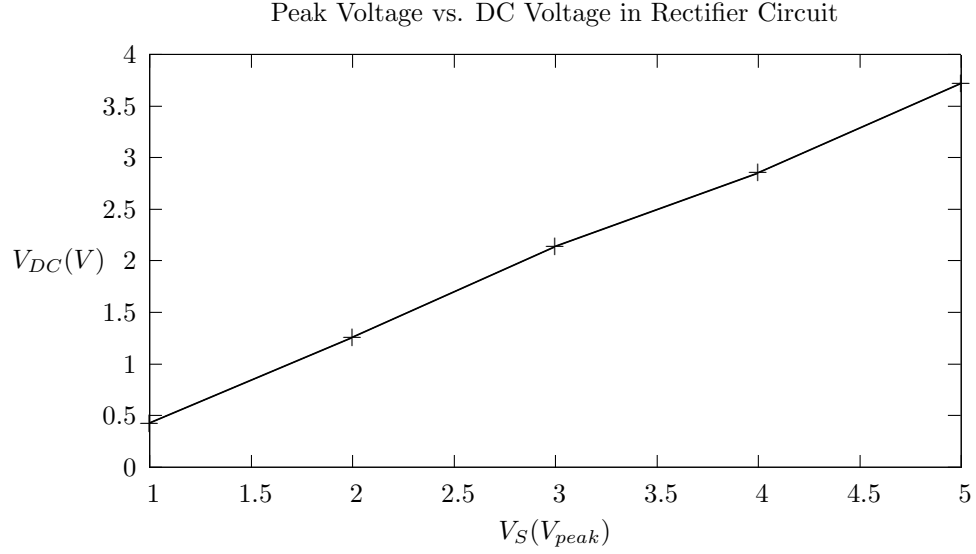


Figure 2: AC input vs. DC output of rectifier circuit, where  $R_L = 10\text{ k}\Omega$

Nominal ( $\Omega$ )	Measured ( $\Omega$ )	Difference
47	46.52	1.13%

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

$R_L$ ( $\Omega$ )	$V_{OC}$ (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

$R_L$ ( $\Omega$ )	$V_L$ (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%
$\infty$	5.38	—	—	—	—

Table 6: Measured values for voltage regulator circuit

$R_L$ ( $\Omega$ )	$V_{OC}$ (% 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 input frequency increases because there would be a smaller time interval for the capacitor to discharge.

As shown in Table 6, the voltage regulation 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

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

$$V_r = V_{max} - V_{min} \quad (2)$$

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