Diode Circuits

Goals and Learning Outcome:

- Explain the I/V curve of a diode
- Build a half wave rectifier
- Design a full wave rectifier with MultiSim
- Understand the role of a capacitive filter on the output of a rectifier circuit
- Troubleshoot faulty diode circuits

Material:

DC Power Supply with Breadboard
Function Generator
2 Tenma Multimeter
Oscilloscope
Rectifier Diodes 1N4001
Resistors 220 Ohm, 1 kOhm

Introduction

A PN junction diode is a device that will conduct current in one direction and block current in the opposite direction. When forward biased to overcome the internal barrier potential, the diode will conduct. Since its forward biased resistance is low, external resistance of the circuit must limit current. When the diode is reversed biased, the diode current is very small.

Assignment 1: Diode Characteristics

Background Theory:

As the forward current through a diode increases, so does the forward voltage across the device. Due to the changing characteristics of the forward-biased diode, V_F will increase at a much smaller rate than I_F. The reason for this behavior is that the forward resistance of a diode decreases as I_F increases.

When the diode is reverse biased, the reverse current I_R through the device will be extremely low, even if there is significant reverse voltage across the device. This is due to the extremely high resistance of the reverse-biased diode. As V_R increases, the width of the depletion layer and thus the junction resistance increases.

Diodes are normally tested by measuring the forward R_F and the reverse resistance R_R. As long as R_F is significantly lower than R_R, the diode is assumed to be good. If R_F and R_R are nearly equal in value, a diode fault is indicated. Low R_F and R_R readings indicate that the diode is internally shorted, whereas a high R_F reading indicates that the diode is internally opened.

Experiment:

1. Connect the diode to an ohmmeter and measure the forward resistance. When making resistance checks of diodes, do not use low meter ranges. Start with highest range and switch

to lower ranges until the value is out of range and you get a "1" on the display. Some ohmmeters can supply sufficient voltage with minimum resistance to damage a low-current diode. In your lab notebook, record the forward resistance R_F.

2. Reverse the ohmmeter leads. Record the reverse bias resistance R_R.

3. Determine the forward bias characteristics of the diode. Construct the circuit as shown in Figure 1 and adjust the source to obtain the required current (I_F) values. At each current value, record the forward voltage (V_F) drop of the diode.

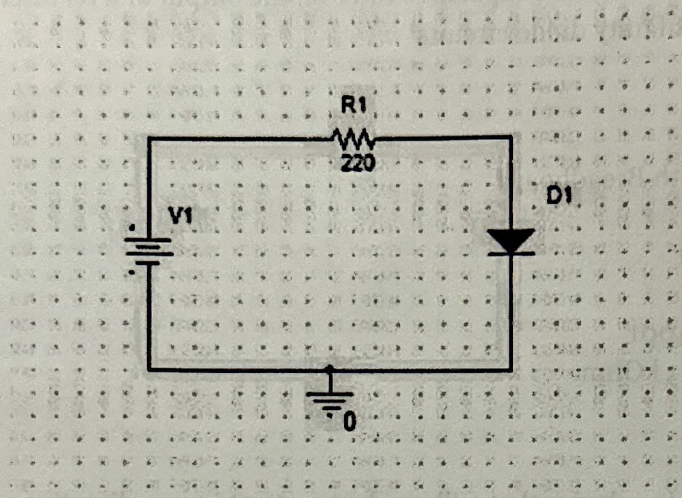

Figure 1: Diode Circuit

4. Create a table similar to the one below in your notebook and record the values of V_F.

I_F	V_F
0.5 mA	
1.0 mA	
2.0 mA	
5.0 mA	
10.0 mA	
15.0 mA	
20.0 mA	
25.0 mA	
30.0 mA	

5. Discuss your results.

Assignment 2: Half - Wave Rectifier

Background Theory:

Rectifier circuits transform ac voltage into pulsating dc waveforms. This is an important first step in the process of obtaining useful, smooth, dc sources from commercial ac power sources. The most important part of a rectifier circuit is its diodes.

The half-wave rectifier consists of a diode and a resistor as shown in figure 2. The ac source is supplying power to a diode and a resistor connected in series. The diode conducts current whenever the applied ac voltage forward biases the diode and the diode blocks current flow through the circuit whenever the applied voltage reverse biases the diode. This means you will find the applied voltage dropped across R_L whenever the diode conducts and zero voltage across the resistor R_L when the diode is non-conducting.

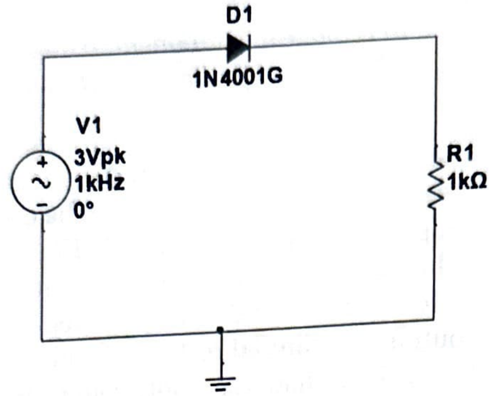

Figure 2: Half-wave Rectifier

Experiment:

1. Build the circuit on the Breadboard. Set the function generator to a peak voltage of 3Vpk.
2. Measure the output voltage across R_L with the oscilloscope. Record the waveform.
3. Reverse the diode and record the output voltage waveform.
4. Add a large capacitor > 2 microfarad in parallel with R_L. How does the capacitor change the waveform? Record the waveform. What is the ripple voltage?

Assignment 3: Full Wave Rectifier (in MultiSim)

In part 3 you will build a full wave rectifier circuit. The purpose of a rectifier circuit is to convert AC power line voltage to DC. Essentially every piece of electronic equipment that operates on AC power must use a rectifier circuit.

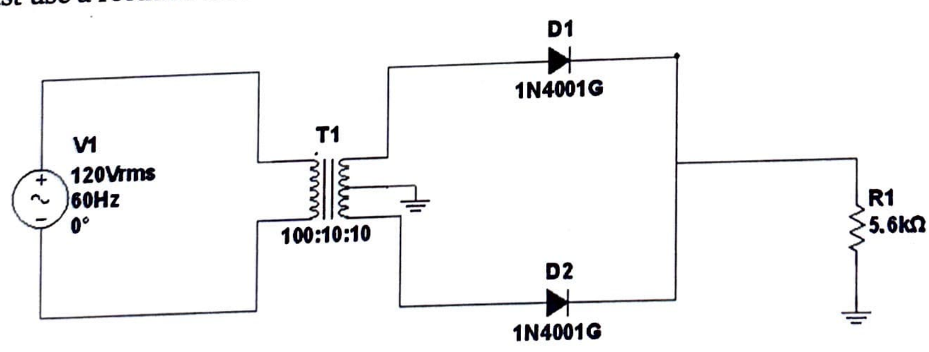

Figure 3: Full Wave Rectifier

1. Connect the circuit as shown in figure 3.
2. Apply power to the circuit and measure the rms transformer secondary voltage V_S. Use the appropriate terminals for a V_S as close to 24 V_{AC} as you can get. Record V_S in your notebook.
3. Predict the peak voltage $V_L(pk)$ and the average DC voltage that will be measured at the load.

4. Using the oscilloscope, first view V_S and record it in Open Choice Desktop. Then view V_{RL} and record the waveform. Do not try to connect both channels to view the two waveforms simultaneously because grounding problems will occur.
5. With the Digital Multimeter or DMM set to read DC voltage, measure the average DC load voltage for the circuit.
6. Disconnect power from the circuit; then remove D1 from the circuit. This simulates and open diode in the rectifier. After removing D1, reapply power to the circuit.

Whenever you are directed to remove a component, a gap should be left where the component appeared in the circuit. Do not bridge the gap left by the missing component unless directed to do so.

7. Add a 10 µF capacitor in parallel to the load resistor and set your oscilloscope to AC Coupling. Using CH 1, observe the output waveform from the circuit and record it in Open Choice Desktop. While viewing the output reduce the V/DIV setting of the oscilloscope until a waveform is seen clearly. This waveform is the ripple voltage. Measure the peak-to peak ripple voltage V_r for the waveform as well as $V_{ave.}$ Repeat step 7 with a 100 µF capacitor. What would happen to the output of a filtered rectifier if you were to replace the capacitor with one of lesser value? Which circuit had less ripple voltage when filtered and why?

Conclusion: Discuss in your own words, what you observed in this exercise.