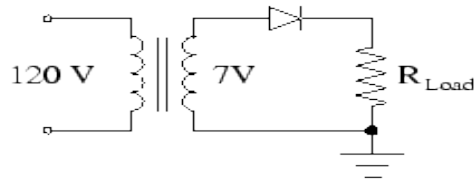# AC TO DC CONVERSION

Half Wave Rectifier

Figure 8: A half wave rectifier.

An important step in converting the 120 V AC power supplied by a standard wall outlet into 5 V DC power for your computer is voltage reduction. You have been provided with a variable transformer that can step the 120 V signal from the wall socket down to 7 V across the two red terminals, or 3.5 V across either black/red pair. In the following exercises, use the 7 V option.

In order to convert an AC current that spends equal amounts of time flowing in opposite directions into a DC current flowing in only one direction, we need a device that responds differently to applied voltages of different polarities. The standard device used for this purpose in modern electronics is the **semiconductor diode**. The circuit of Figure 8 is called a **half wave rectifier**, because the diode simply blocks the segments of the signal with negative polarity.

Set up the circuit of Figure 8 using a 10 k Ω load resistor, and compare the voltage across the load resistor to the input signal. Are you surprised by the peak voltage across the load? Make note of this. Also compare your observations with a Spice simulation (a transient analysis). If they agree, just hand in a graph of the simulation. Otherwise, also sketch your observed oscilloscope traces.

In your Spice simulation, do not explicitly include the transformer. Simply treat it as a sinusoidal voltage source. In order to use diodes in a circuit, include the following statement somewhere in your circuit file.

.MODEL D1 D

This tells Spice that device type D1 is a generic silicon diode. Then, diodes are specified with the syntax

[Name] [+] [-] D1

where the [Name] field must begin with a D, and current is allowed to flow from the [+] node to the [-] node.
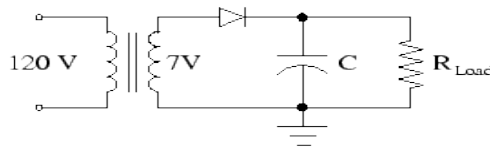

Figure 9: A half wave rectifier with a filter.

You should have found that the load is not being driven by a particularly steady DC signal, although the current always moves in one direction.

(If you did not, perhaps we should look at what you discovered together.) The next step is to use a large capacitor to filter out most of the unwanted variation or **ripple** in the signal across the load resistor. The circuit of Figure 9 includes a filter capacitor in parallel with the load. Since the diode does not allow current to flow back through to the transformer, the capacitor discharges through the load resistor with a time constant $R_{Load}C$. Assuming $R_{Load}C >> \frac{1}{f}$ derive an expression for the peak to peak magnitude of the ripple in the output signal in terms of C and R_{Load}. Assuming a 10 k Ω load, find the capacitances you would need to use to reduce the ripple to 10% and 1% of the DC output voltage.

Using the best filter capacitor you can find [3], measure the DC level and the magnitude of the ripple across the load. Use the DC (direct coupling) mode of the oscilloscope or a DVM to measure the the DC level, and use the AC (active coupling) mode of the oscilloscope to remove the DC component of the signal and zoom in on the ripple. Then change the load resistance, and determine whether the ripple changes as expected.

Full Wave Rectifier

The configuration of four diodes in the circuit shown in Figure 10 is called a **bridge rectifier**.

It is also a **full wave rectifier**, because it does not throw away any part of the input signal.
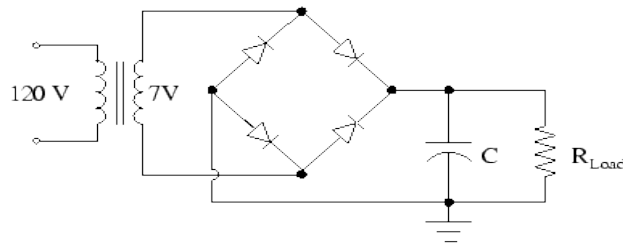

Figure 10: A full wave rectifier with a filter.

Consequently, the filter for this circuit requires roughly half the time constant of the half wave rectifier.

Build the circuit of Figure 10 using a 10 k Ω load resistor and a suitable filter capacitor, and compare your observation of the voltage across the load resistor, with and without the filter capacitor, with Spice simulations. [4] If they agree, just hand in a graph of the simulation. Otherwise, also sketch your observed oscilloscope trace. Measure the magnitude of the ripple, change the load resistance, and determine whether the ripple changes as expected.

A ``Real'' DC Power Supply

You have been given an open power supply constructed as shown in Figure 11. This supply is a full wave rectifier with a filter and a device called a **voltage regulator** that removes the remaining ripple.
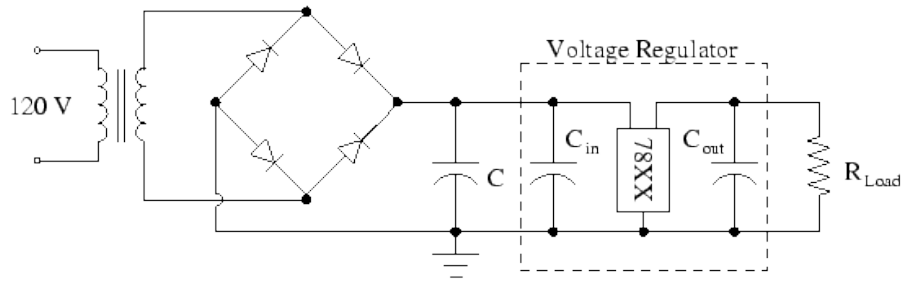
Figure 11: A full wave rectifier with a voltage regulator.

This device is an **integrated circuit** (IC) that contains lots of very small resistors, capacitors, diodes and transistors manufactured on a single silicon wafer. For the moment, we will treat it as a ``black box.'' Its function is to deliver or accept current as needed to maintain a constant output voltage. The 78XX series of voltage regulator maintains an output voltage of XX Volts. Your supply has a 7806, so the DC output voltage should be close to 6 V.

Poke around carefully with the oscilloscope. The filter capacitor is physically the largest capacitor. It also has the largest capacitance. (The other two capacitors, labelled C_{in} and C_{out} are recommended by the manufacturer of the voltage regulator.) Measure the DC and ripple voltages both at the output and at the filter capacitor.