Diodes as Rectifiers

As previously mentioned, diodes can be used to convert alternating current (AC) to direct current (DC). Shown below is a representative schematic of a simple DC power supply similar to a automobile battery charger. The way in which the diode rectifier is used results in what is called a half-wave rectifier.

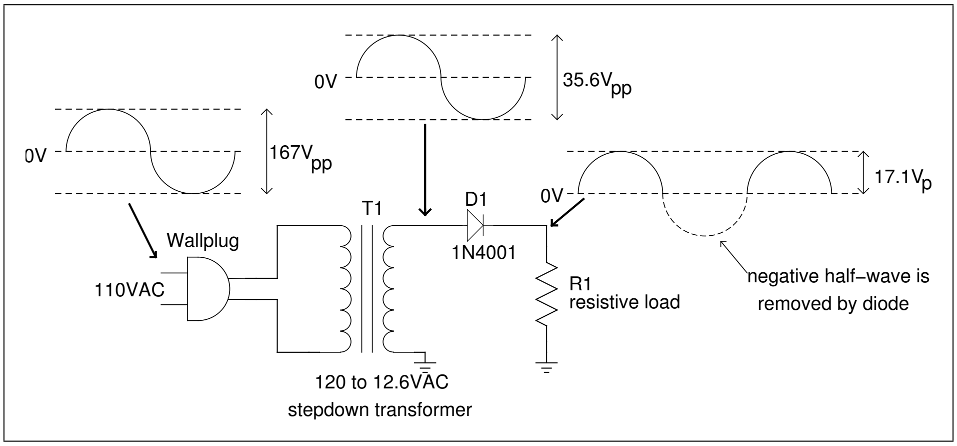

Figure 1: Half-Wave Rectifier Schematic

The input transformer steps the input voltage down from 110VAC(rms) to 12.6VAC(rms). The diode converts the AC voltage to DC by removing the negative going part of the input sine wave. The result is a pulsating DC output waveform which is not ideal except for simple applications such as battery chargers as the voltage goes to zero for one have of every cycle. What we would like is a DC output that is more consistent; a waveform more like a battery what we have here.

We need a way to use the negative half-cycle of the sine wave to to fill in between the pulses created by the positive half-waves. This would give us a more consistent output voltage. Below is a circuit that does just that. When the diodes are connected in this manner this circuit would be called a full-wave rectifier.

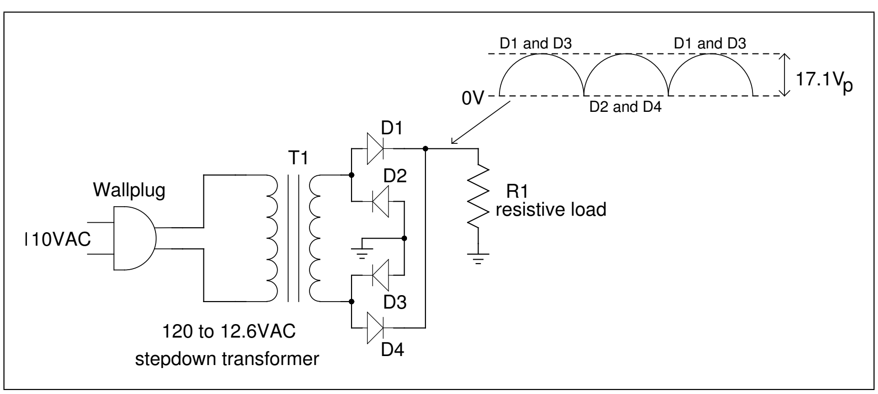

Figure 2: Full-Wave Rectifier Schematic

The full wave rectifier uses the one-way action of the diodes to create the output from both positive and negative half-waves of the AC input signal. The path through the load passes through two diodes in this scheme. The different paths through the rectifier are shown below.

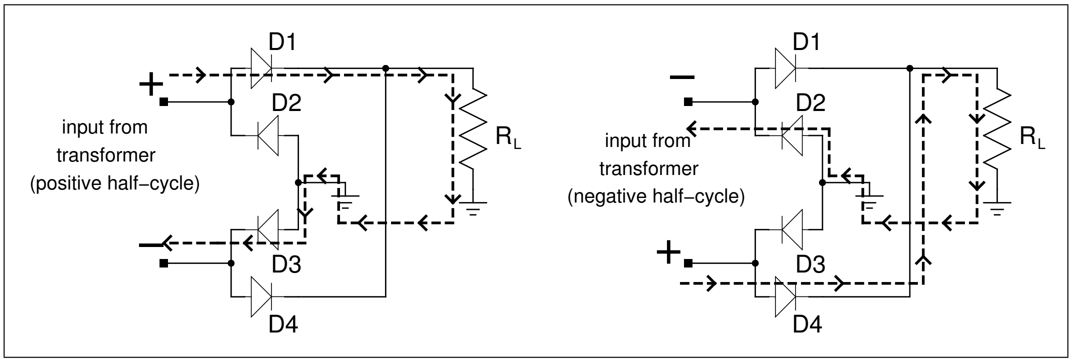

Figure 3: Different Paths through the Rectifier Diodes

When the the top terminal is more positive, only diodes D1 and D3 can conduct. Because of the voltage drop across the load, diode D2 is reverse biased. Diode D4 is reverse biased from its connection across the transformer. As the current passes through each diode, the voltage drops by 0.7 volts. Thus, even if the load was a short circuit, diode D2 could not pass current back to the input terminal since its anode side is at least 0.7 volts below its cathode because of diode D1. When the bottom terminal is more positive, only diodes D4 and D2 can conduct. In either positive or negative half-cycles, the positive output terminal remains positive.

Now we have an output that is uni-polar put still has *ripple*. We can remove most of the ripple with the addition of a capacitor shown below. The capacitor acts as a temporary storage reservoir that supplies current to the load between the input pulses. The capacitor is charged on the rising edge of the half-cycles and supplies current to the load when the input voltage falls below the voltage stored on the capacitor. Such a circuit is able to provide a fairly clean output that is suitable for most electronic devices.

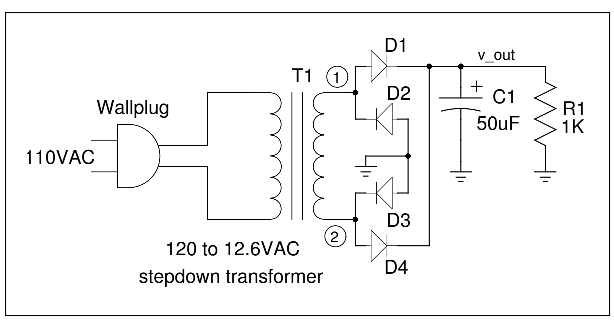

Figure 4: Full-Wave Rectifier with Filter Capacitor Schematic

The output from a spice simulation of the full-wave rectifier is shown in fig 5. The red trace is the input voltage. The blue trace is the output voltage. After the input waveform begins to fall below the capacitor voltage, we see the discharge of the capacitor begin. Once the *inverted* negative half-cycle voltage exceeds the capacitor voltage, we see the capacitor being recharged. The capacitor *holds-up* the voltage between the voltage peaks. With an big enough capacitor the voltage droop between input voltage peaks can be made arbitrarily small.

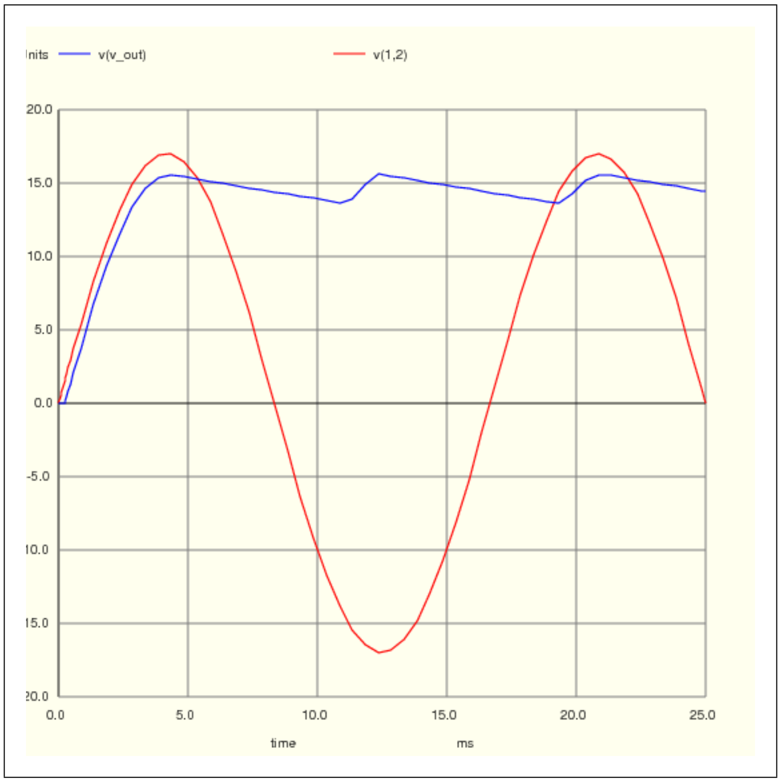

Figure 5: Spice Simulation - Filtered Full-wave Rectifier Showing Output Ripple