Physics 231 - Diodes & Rectifier Circuits (Exp. 6)

In this lab you will build some simple rectifier circuits that can be used to convert AC signals which vary in time to constant DC voltages.

Diodes act as one-way valves for current: current can pass through the diode in one direction, but not the other. In order for a diode to conduct, the potential at the p-type side must exceed the potential at the n-type side by at least V_{d}, where V_{d} is typically between 0.6 and 0.7 V for silicon diodes.

1. HALFWAVE RECTIFIER

Construct the "halfwave" rectifier circuit shown in Fig. 1.

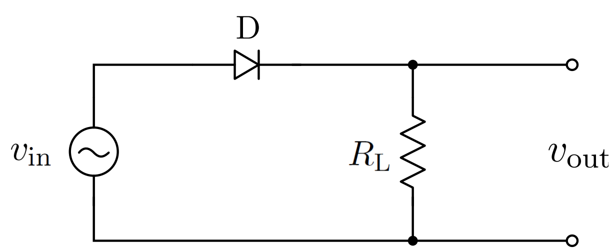

Figure 1: The halfwave rectifier.

(i) Use an IN4148 diode and $R_{\mathrm{L}} = 1\,\mathrm{k}\Omega$. Set your function generator to output a 1 kHz sine wave with an amplitude of 10 V and observe v_{in} and v_{out} on the oscilloscope. What is the peak value of v_{out}? Does this agree with what you'd expect?

(ii) Now also use a DMM to measure v_{out} (in parallel with the oscilloscope measurement). Set the DMM to DC mode, which will measure the average value of v_{out}. Recall that the average value of a function over time interval T is given by:

$$\overline{f} = \frac{1}{T}\int_{t_0}^{t_0+T} f(t)\,dt.$$

Use this expression to estimate the expected value of $\overline{v_{\mathrm{out}}}$ over one period. Does your calculation agree, within reason, with the measured DC voltage.

(iii) Now set the DMM to AC voltage mode to measure the rms value of v_{out}. Record the value.

2. IMPROVED HALFWAVE RECTIFIER

Add a 1 µF capacitor in parallel with R_L as in Fig. 2.

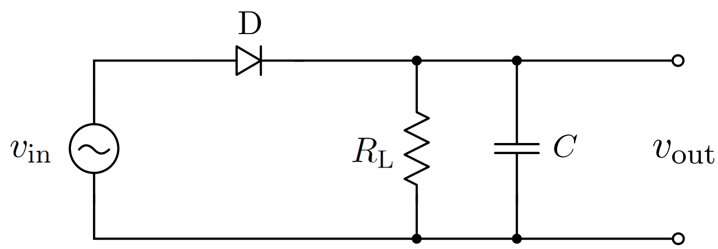

Figure 2: The halfwave rectifier with parallel capacitor at the output.

(i) Measure the peak voltage of v_out. How does it compare to 1(i)?

(ii) Measure the DC voltage of v_out. How does it compare to 1(ii)?

(iii) Measure the rms voltage of v_out. How does it compare to 1(iii)?

(iv) Let's call the DC component of V_DC and the AC component v_rms. We can then define a quantity called the "ripple factor" as $r = v_\mathrm{rms}/V_\mathrm{DC}$. In a high-quality rectified circuit (or AC-to-DC converter) one desires $v_\mathrm{rms} \ll V_\mathrm{DC}$ such that r is very small.

Measure r for the circuit in Fig. 2 for 10 frequencies between 1 kHz and 10 kHz. Make a plot of r versus $1/f$. You will show that r and f are inversely related in one of your assignments.

3. FULLWAVE RECTIFIER

Construct the "fullwave" rectifier circuit shown in Fig. 3.

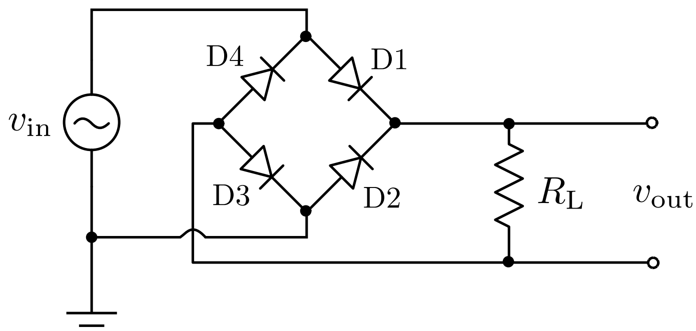

Figure 3: The fullwave rectifier.

(i) Again, use an IN4148 diodes and $R_{\text{L}} = 1\,\text{k}\Omega$. Set your function generator to output a 1 kHz sine wave with an amplitude of 10 V. In order to observe v_{out} on the oscilloscope, you will have to use both channels and math mode. You will note be able to simultaneously observed v_{in} on the oscilloscope. You should now see clearly why the first circuits in parts 1 and 2 are known as the halfwave rectifiers and the circuit in Fig. 3 is known as a full wave rectifier.

4. IMPROVED FULLWAVE RECTIFIER

Add a 1 µF capacitor in parallel with R_L as in Fig. 4.

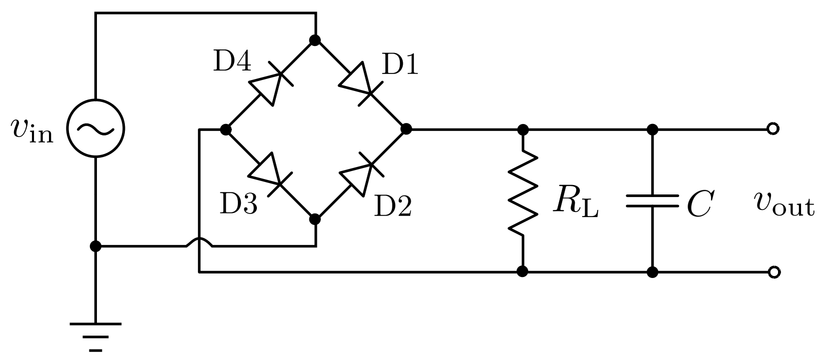

Figure 4: The fullwave rectifier with parallel capacitor at the output.

(i) Measure the peak voltage of v_{out}. How does it compare to 2(i)?

(ii) Measure the DC voltage of v_{out}. How does it compare to 2(ii)?

(iii) Measure the rms voltage of v_{out}. How does it compare to 2(iii)?

(iv) What path does the current take when v_{in} is positive and greater than V_d? Which diodes are conducting and which ones are not conducting?

(v) What path does the current take when v_{in} is negative and its magnitude is greater than V_d? Which diodes are conducting and which ones are not conducting?