Diode applications

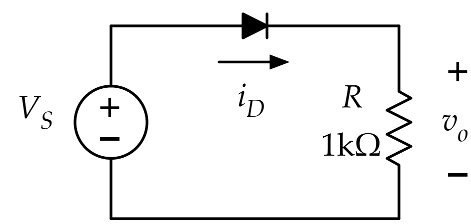
This time, we look at some circuits that use diodes.

Note

The voltage source for all of the circuits is a 6.5-V_{RMS} output from the transformers in the lab. As you may recall from 201, the transformers have 3 output nodes. Between the outer two connectors, the voltage is 13-V_{RMS}, and between the inner connection and either of the outside connections is 6.5-V_{RMS}. Be sure to measure the transformer outputs before connecting it to your circuit, to make sure that you are using the correct voltage levels. Note that the first few circuits are direct repeats of measurements that (some of) you did in EE 201.

A. Half-wave rectifier circuit

Use a 1N4006 diode to build the half-wave rectifier shown at right.



Observe the source and resistor voltages together on the oscilloscope. Record an image for the report.

Figure 1. Half-wave rectifier.

Turn the diode around to rectify the negative half of the sine wave. Record an image of that as well.

For fun, replace the 1N4006 with one of the LEDs from your kit. Note any differences in the rectified output waveform.

B. Full-wave rectifier

Use four 1N4006 diodes to build the full wave rectifier, as shown in Fig. 2. Observe the rectified output voltage on the oscilloscope. Save a copy for your report. Note that you cannot view the source and output voltages together, because they do not share a common connection that can used as the oscilloscope ground. If you try to view both simultaneously, you will be shorting out one of diodes, and things will look very weird.

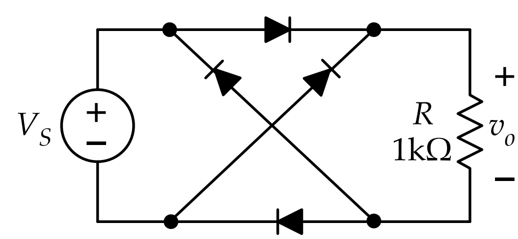
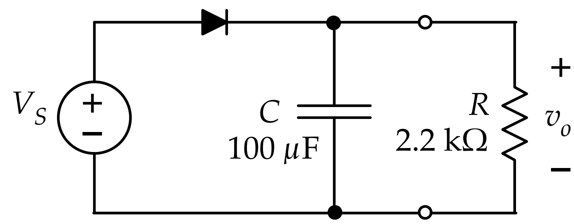


Figure 2. Full-wave rectifier.

C. Peak rectifier circuit

Build a half-wave rectifier, and add a 100-μF capacitor to make a peak rectifier, as shown in Fig. 3. For the sinusoidal source, use the function generator, set to a frequency of 60 Hz and an amplitude of 5 V_{RMS} (peak voltage of 7.07 V). (For this lab, we are using the function generator in place of a transformer.) Pay attention to the polarity on the electrolytic capacitor — getting it wrong may have explosive results! Observe the source and output voltage waveforms together on the oscilloscope. Use the same voltage scales and zero points so that the output voltage is sitting “on top” of the source, just like in the notes or the text. Save a copy for your mini-report.

Figure 3. Peak rectifier.



Use the cursors on the oscilloscope to measure the ripple voltage [v_o(max) – v_o(min)]. Use the multimeter on the DC voltage setting to measure the average output voltage. Compare these measured ripple and average voltage to calculated values, using the equations derived in class (or in the book).

Next, change the meter setting to AC volts and record the measured value.

An aside: On the AC setting, the multimeter is attempting to measure the “ripple”. However, the meter will be a bit confused, because it thinks it is measuring a sinusoid. and the value reported is based on that interpretation. The number given by the meter is useful for comparing one measurement to another, but it cannot be used to compare a measurement to a calculation. In comparing measurements to calculations, you can only use the measurements taken with the oscilloscope. However, when the ripple becomes very small, it is difficult to measure it using the oscilloscope, and the then the “estimate” provided by the multimeter is more useful.

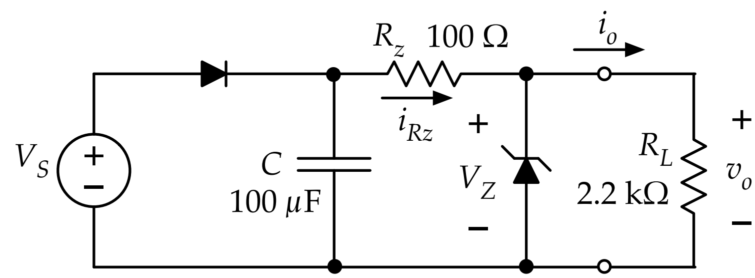
Replace the 2.2-kΩ resistor with a 1-kΩ resistor. Save a copy of the input and output waveforms together. Repeat the ripple measurements (using both the oscilloscope and the meter set to AC volts) and average (DC) voltage measurement. Then, replace the 1-kΩ resistor with a 4.7-kΩ resistor and repeat the measurements one more time. Compare the measured results with calculated values.

Return to the original circuit with the 2.2-kΩ resistor. Increase the input sinusoid to 6.5 V_{RMS} and repeat the ripple and average voltage measurements. Finally, increase the input sinusoid to 8 VRMS and measure the ripple and and average voltage one last time. Compare these measured results with calculations.

D. Simple Zener regulator

Add a simple Zener regulator circuit between the capacitor and load resistor, as shown in Fig. 4. Use the 1N4733 (5.1-V) diode for the Zener. The sinusoidal source voltage is again the function generator set to 5 V_{RMS} and 60 Hz.

Figure 4. Half-wave peak rectifier with simple Zener regulator.

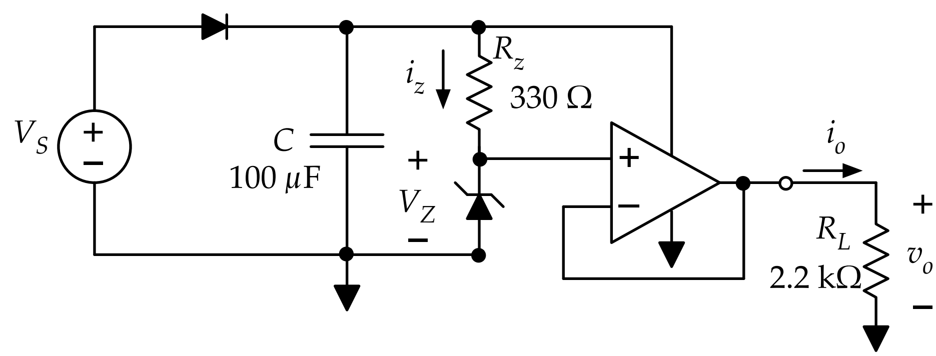


Repeat all the measurements from part C. (Different load resistance and different source amplitudes.) Note that it may be difficult to measure the ripple voltage using the oscilloscope, because the ripple should be much smaller. (Of course, this is the point in using the regulator circuit.) Record the ripple and the average voltages measured using the meter.

E. Op-amp Zener regulator

Now use the regulator circuit shown in Fig. 5. Use an LM324 op amp and the 1N733 (5.1 V) Zener.

Figure 5. Op-amp based regulator.



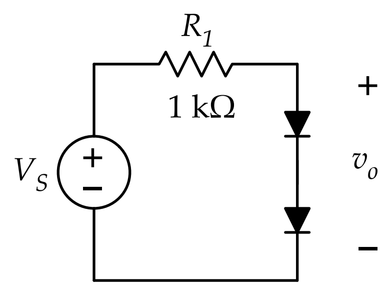
The op-amp is in the unity-gain configuration, so the output voltage should be equal to the Zener voltage.

Record a trace of the input and output voltages together. Then repeat the ripple and average voltage measurements for the various load resistance and source voltage amplitudes performed in parts C and D.

F. Clamping (limiting) circuits

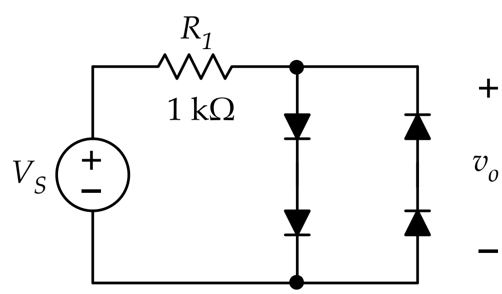
Build the circuit shown in Fig. 6. The source is still one of the 6.5-V_{RMS} secondary connections of the transformer. This is similar to the rectifier circuit, but the output is taken across the pair of diodes. Observe the output voltage together with the input on the oscilloscope. Record a good trace for the report.

Figure 6. Positive-side limiter.



Finally, limit both the positive and negative of the source using the circuit of Fig. 7. Observe the input and output together on the oscilloscope, and record a copy of the trace for your report.

Figure 7. Positive and negative limiter.



Reporting

Prepare and submit a report after you have finished the lab. Each lab group is required to submit a report (i.e. one report for two people). Be sure to include all of the oscilloscope waveforms and multimeter measurements where needed. The report is due in one week.