

Physics 334

Notes for Lab 3 – Diodes and Rectifiers

January 26, 2009

Lab manual sections **3-1 through 3-6; 3-7** and **3-8** are optional.

Beginning with this lab you should measure 'scope signals with the x10 'scope probes. These probes increase the input impedance to the 'scope by a factor of 10. This helps keep the scope circuit from loading the circuit you are testing. When using these, you need to either remember that the signal is 10 times larger than is actually shown on the scope, or set the “PROBE” softkey (available under the CH1 or CH2 menu) to “X10”.

If you do things correctly, you will not burn out diodes or fuses. If you blow a fuse, there is a REASON. Fuses will last a very long time indeed if they are not destroyed by miswiring. Find it before replacing it and blowing another.

If your transformer box light goes out, first, double check that all diodes are good by testing with the DMM diode test setting. If all test good, you should verify that both the transformer and circuit on the breadboard are wired correctly. Only when you have located your problem should you have your TA replace the fuse. You should be sure that anyone replacing the fuse unplugs the transformer box while doing so for an added measure of safety, so that no components are live while there is any possibility of contact with your hands.

- 3-1. The 10mH inductor is a small blue cylinder with two leads, in the parts cabinet drawer labeled as containing the inductor.

The resonant frequency (expressed in terms of the angular frequency ω is $\omega_{\text{res}} = 1/\sqrt{LC}$. Double check that you're using the right equation if you find yourself off by a factor of 2π .

Connect both the input signal and the output signal to the two channels of the scope, and trigger on the input signal. Then note the resonant frequency and the phase shift as you pass through resonance.

Skip the rest of section 3-1 starting with “Use the function generator’s sweep feature. . .”

- 3-2. Before wiring this up, check your diode with one of your DMMs set on the “diode check” setting (find the picture of the diode symbol). With the meter leads hooked up one way, you will see “OL” or some such expression; with the leads the other way you should read a voltage in the range 0.6–0.7 volts. If you don't see this behavior, you have a bad diode. When the diode is forward biased (anode positive relative to the cathode), you'll see a 0.6 Volt drop

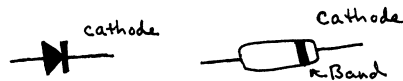
and conduction. A reversed biased diode does not conduct appreciably and therefore reads “OL”.

Again, as before, you can use any two “taps” on the transformer for this exercise. Leave the 3rd remaining tap open. You’ll get a signal that’s twice as large if you use to far left and far right taps. Our transformers are a variety sometimes called a “center tap” transformer. What do you think that means based on the above?

Do the exercise as in the text. Sketch what you see on the scope: put one probe on the back end of the diode and the other on the front end, and compare the waveforms. Triggering can be done on the line voltage. This is one exercise where you might find triggering on “LINE” to be better than “INT”.

- 3-3. *Read through all of the manual’s instructions in this part BEFORE building the circuit. It is very easy to fry diodes or blow fuses on this exercise. Test your diodes first before building the circuit and be very careful of the polarity of the diodes.*

Remember the convention:



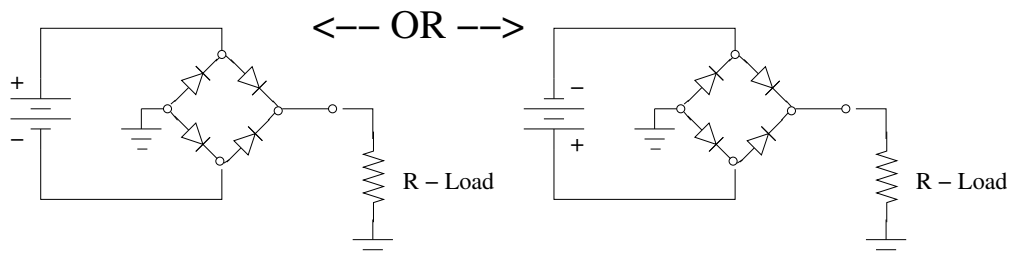
Again use only 2 taps on the transformer – Whichever two make you happy. I use the outer two to get a slightly bigger signal. To keep things simple you can use the ground of the scope probe for the ground connection on the left most side of the bridge.

DO NOT ground the 3rd or center tap on the transformer. (What happens if you do?) Note the books caution that you should not attempt to look at the input of this circuit with your scope.

Students are frequently baffled by the transformer, especially when they look at this circuit. Fear not, it’s simpler than it at first appears. If it still leave you feeling befuddled, perhaps this will help.

REMEMBER: The transformer is just like a battery that continuously changes it’s voltage. If it’s still baffling to you, a simplified model might help.

The output of the transformer can be thought of as being very similar to the following two conceptual diagrams:



In each case, two of the diodes are conducting to complete the circuit. (Which two in each case?) Of course our transformer puts out a sine wave, not a DC voltage... but maybe this

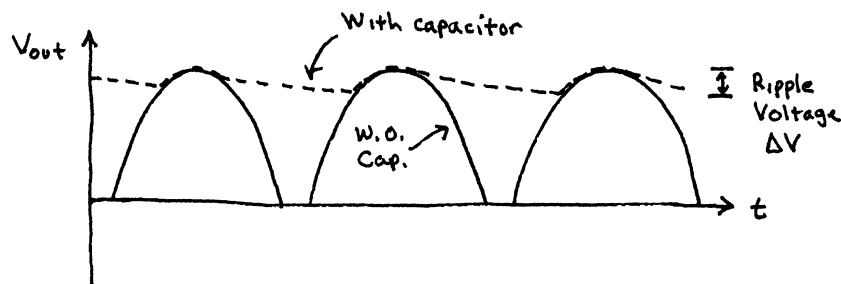
will help you to better understand how the circuit works. So the transformer output with a rectifier is like a circuit that slowly varies between these extremes.

Answer all questions in the discussion. “Open” failure means the diode has an infinite resistance, like what happens when a fuse blows. “Closed” failure means the diode acts like a wire.

You can give a *quantitative* answer to the duration of the flat regions of the waveform near zero volts, but a *qualitative* explanation is acceptable.

- 3-4. When you connect the capacitors across the output of the circuit in 3-3, draw pictures of the resulting waveforms for both the $15\mu\text{F}$ and $500\mu\text{F}$ varieties. (Note: if you don't have a $500\mu\text{F}$ cap, use $470\mu\text{F}$ or other similarly large cap.)

You can calculate the predicted ripple voltage by following the method in the manual's class notes, pp. 68–69. This will tell you if the output “makes sense.” The drawing below shows what is going on



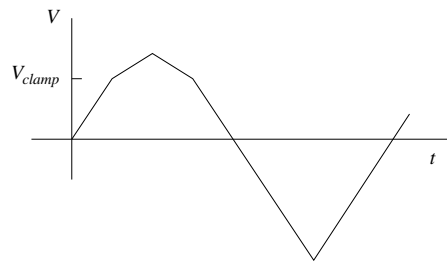
Since $C\Delta V = I_{\text{load}}\Delta t$, and since $\Delta t \approx T/2 = 1/2f$ then $\Delta V \approx I_{\text{load}}/(2fC)$.

- 3-5. Again, draw pictures of the input and output waveforms and discuss: why does the output have the shape that it does?

Further hint on effect of removing 2.2k resistor: The 'scope is connected to the output. What does this instrument add to the circuit? Draw an equivalent circuit including the 'scope's input impedance.

- 3-6. To estimate the dynamic resistance of the diode, apply a triangle wave to the input and compare the input and output waveforms. The output should show a flattened triangle. The height of the upper piece from the point where it begins to turn downward to the tip gives ΔV across the diode. The difference between the tip of the output wave and the tip of the input wave gives ΔV across the 1k resistor, and hence, the current in the diode. From these you can get the dynamic resistance.

Answer all of the questions in the exercise. “Bypass” in this instance means that some signals are “shunted off to ground”. Try measuring the signal at the cathode end of the diode, with and without the capacitor. The figure in the text looks like this:



3-7. (Suggested, but optional) Try this if you have time.

3-8. (Suggested, but also optional.) You should read through it and see if you can understand the ideas.