Physics 120 Lab 3: Harmonic Analysis and Diode Circuits

3-1 LC Resonant Circuit

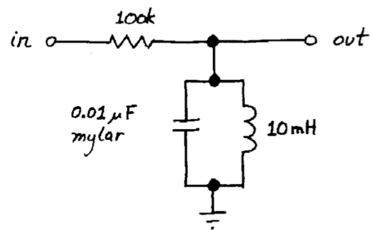

Figure 3.1: LC parallel resonant circuit

Construct the parallel resonant circuit shown above. Drive it with a sine wave, varying the frequency through a range that includes what you calculate to be the circuit's *resonant frequency*. Compare the resonant frequency that you observe with the one you calculated (The circuit attenuates the signal considerably, even at its resonant frequency because the inductors includes some series resistance. Thus start with a 10 V signal). Illustrate resonance with a series of **SCREENSHOTS**.

Finding Fourier Components of a Square Wave

This resonant circuit can serve as a "Fourier Analyzer:" the circuit's response measures the amount of 16 kHz (approximately) present in an input waveform.

Try driving the circuit with a square wave at the resonant frequency; note the amplitude of the (sine wave) response. Now gradually lower the driving frequency until you get another peak response (it should occur at 1/3 the resonant frequency) and check the amplitude (it should be 1/3 the amplitude of the fundamental response). With some care you can verify the amplitude and frequency of the first three nonzero terms of the Fourier series. Report your results and illustrate them with **SCREENSHOTs**

Here is a reminder of the Fourier series for a square wave:

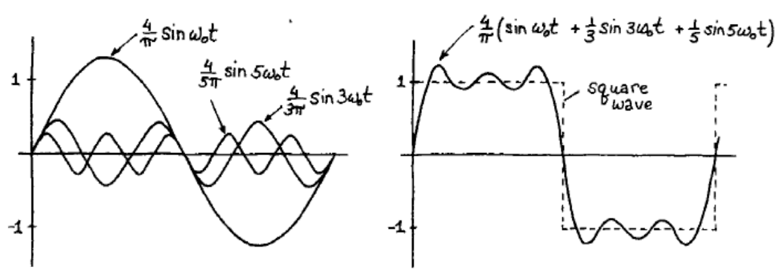

Figure 3.2: Fourier series for square wave

"Ringing"

Now try driving the circuit with a low-frequency square wave: try 20 Hz. You should see a brief output in response to each edge of the input square wave. If you look closely at this output, you can see that it is a decaying sine wave.

What is the frequency of this sine wave? (No surprise here!) Why does it decay? Does it appear to decay exponentially? Document this with a **SCREENSHOT**.

3-2 Half-wave Rectifier.

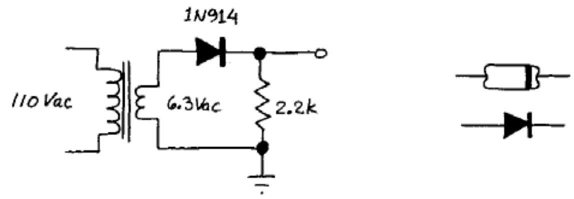

Figure 3.3: Half-wave rectifier

Construct a half-wave rectifier circuit with a 6.3VAC (RMS) transformer and a 1N914 diode, as in the figure above. Connect a 2.2 kΩ load, look at the input as well as the output on the oscilloscope using scope probes, and take a **SCREENSHOT**. Is it what you expect? Can you comment on the polarity of the signal? What happens if you reverse the direction of the diode. (Don't be troubled if $|V_{peak}|$ is a bit more than $6.3\,V \cdot \sqrt{2}$: the transformer designers want to make sure it meets specifications a under heavy load)

3-3 Full-wave Bridge Rectifier.

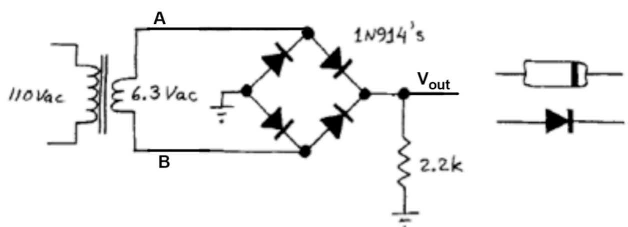

Figure 3.4: Full-wave bridge

Now construct a full-wave bridge circuit, as above, with the output of the transformer "floating". Be careful about polarities – *the black band on the diode indicates cathode (negative), as in figure 3.4*. Look at the output waveform and take a **SCREENSHOT.** *Do not attempt to look at the floating input yet (and certainly do NOT ground either end of the output of the transformer - or poof!*)

Don't be alarmed if you find yourself burning out diodes in this experiment. Do you see why diodes in this circuit usually fail in pairs?

Look at the region of the output waveform that is near zero volts. Why are there flat regions? Measure their duration, document it in your report with a **SCREENSHOT** and explain.

What would happen if you reversed any one of the four diodes? Just answer this - do not try it!

For extra credit: Use a pair of scope probes to measure the output of the transformer in a differential manner. Connect one channel (say Ch3) to one output lead (A in Fig. 3.4), the second channel (say Ch4) to the other lead (B in Fig. 3.4), and connect the probe grounds to Common. Make sure both channels have the same gain and are DC coupled, then use a MATH function to take the difference Ch3 - Ch4. What do you see for Ch3, Ch4, and their difference? Take a **SCREENSHOT**.

3-4 Ripple.

Now connect a 15 μF electrolytic capacitor in parallel with the output resistor (*Observe the polarity of the capacitor or it too can go poof!*). Does the output make sense? Document it with a **SCREENSHOT.** Estimate what the "ripple" amplitude should be, then measure it. (*Hint*: You can do this exactly by the convolution integral of the full-wave rectified sine with a low-pass filter, as in the notes. Or, you can estimate the "ripple" amplitude from the nearly linear discharge of the waveform. Use the cursors on the oscilloscope to estimate the discharge time and recall that the initial decay of an RC circuit goes as t/RC). Does it agree?

Now put a 470 μF capacitor in parallel with the output resistor and see if the ripple is reduced to the value you predict. Document this with a **SCREENSHOT.** This circuit is now a respectable voltage source, for loads of low current.

3-5 Signal Diodes.

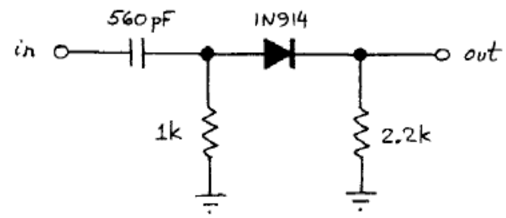

Figure 3.5: Rectified differentiator

Use a diode to make a rectified differentiator, as in the figure above. Drive it with a square wave at 10 kHz or so at 1 Volt amplitude, or more. Look at input and output, using both scope channels, and take a **SCREENSHOT**. Do the waveforms make sense? What does the 2.2 kΩ load resistor do? Removing it and note what happens.

Hint: You should see what appears to be RC discharge curves in both cases – with and without the 2.2 kΩ to ground. The challenge here is to figure out what determines the R and C that you are watching.

3-6 Diodes Clamp.

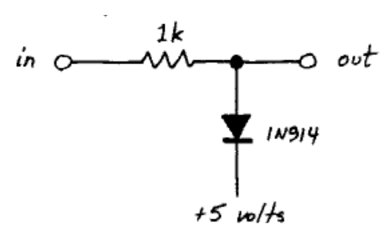

Figure 3.6: Diode clamp

Construct the simple diode clamp circuit shown just above. Drive it with a sine wave from your function generator, at a 10 V amplitude, and observe the output and document it with a **SCREENSHOT.** If you can see that the clamped voltage is not quite flat, then you can see the effect of the diode's non-zero impedance. Document your results.

3-7 Diode Limiter.

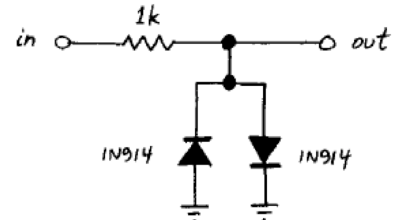

Figure 3.7: Diode limiter

Build the simple diode limiter shown above. Drive it with sine waves, triangle waves, and square waves of various amplitudes and document your results. Present these results with **SCREENSHOTS.** Describe what the circuit does, and why. Can you think of a use for it?