# University of Utah
# Electrical & Computer Engineering Department

ECE 2100

Experiment No. 5

# Doubler Trouble

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rev, 2/11/03

Minimum required points = 48 Grade base, 100% = 68 points
Recommend parts = 68 points (100%, ALL parts are recommended this time)

## Objectives

1.) Examine clippers, clampers, and doublers
2.) See AM modulation and a simple detector

## Check out from stockroom:

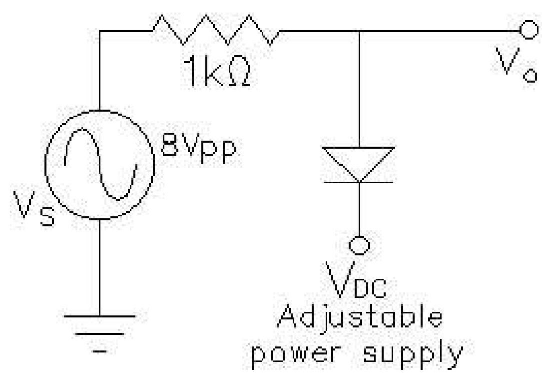
- Wire kit
- Two 10x scope probes

Note: In Experiment 4, AM Detector, you'll need to use one of the HP signal generators mounted in the benches at the east side of the lab.

## Parts to be supplied by the student:

These items may be bought from stockroom.

- 1 kΩ, 10 kΩ, and a few larger resistors
- 0.1 µF or 0.22 µF & two 1 µF capacitors
- two Small signal or switching diode (1N4148)
- Zener diode rated from 3 to 6 V
- Proto-board and wires



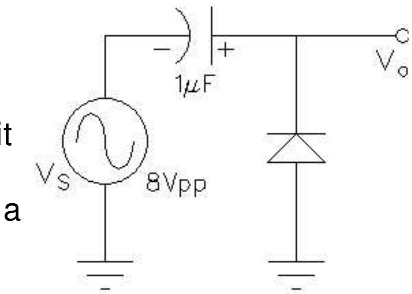

## Experiment 1, Clippers (28 pts, Recommended)

Build the simple clipper circuit shown above-right. For $v_s$, use about an 8 $V_{pp}$ (4 $V_{pp}$ on HP) sine wave at about 1 kHz. $V_{DC}$ is the output of an adjustable DC power supply, set at 0 V for now. Observe the output of this circuit with the scope and vary the DC supply voltage. At some level of interest to you, record the input voltage, the DC voltage, and sketch the output voltage waveform in your notebook. Comment on how this circuit works and the effects of changing the DC input.

Switch the leads to the DC power supply (change + to - and vice versa) to obtain a negative DC, and vary the DC voltage again. At some level of interest to you, record the DC voltage and sketch the output in your notebook.

**Zener clipper:** Replace the diode with your zener diode and resketch the circuit to show the orientation of the zener in your circuit. Vary the DC supply voltage and possibly switch its leads to get an output that is clipped by at least a volt on both top and bottom. Turn up the AC input if you have to. Record the DC voltage and the clipping levels and sketch $v_o$ in your notebook. Why does it clip on both top and bottom?

Add the original diode in series with the zener to prevent the forward biasing of the zener diode. Comment on the clipping with both diodes, do any clip levels change?



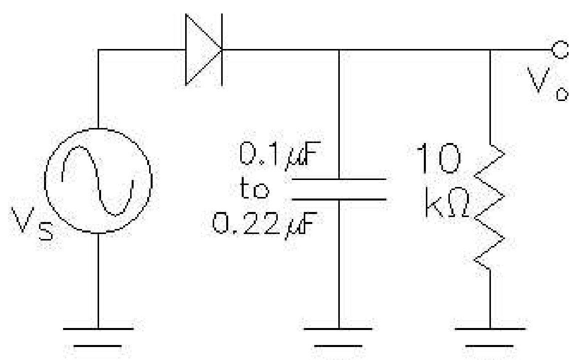

## Experiment 2, DC Restorer (10 pts, Recommended)

Build the DC restorer (also known as clamped capacitor) circuit shown. Sketch the output in your notebook. Measure the DC voltage at the output and across the capacitor. Conclude with a comment on the workings of this circuit.

## Experiment 3, Voltage Doubler (18 pts, Recommended)

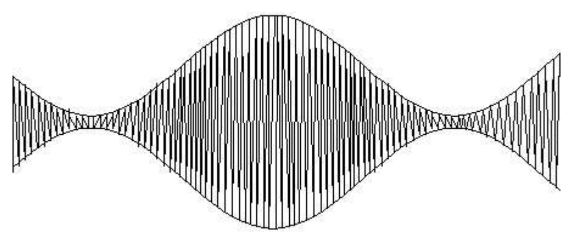
Build the doubler circuit that you have analyzed or will analyze with SPICE (See p.205 in your book). (Think about the polarity of the second capacitor.) Use the same parts values and input voltage. Try out the circuit in exactly the same configurations that you were asked to run in SPICE (no load resistor, 1 kΩ load, and 10 kΩ load) and make a sketch of the output with the in each case. Each sketch should show the DC voltage and the approximate ripple or variation of the DC so that you will be able to compare your lab results to your spice results. Comment on the workings of this circuit.

If you have your SPICE output, compare your actual circuit results to those you got with SPICE, otherwise, look at the plot of $v_3$ ($v_O$) on page 205 of your textbook. Why don't you see the stepping waveform (initial transient) in the lab that you see in the computer outputs?




## Experiment 4, AM Detector (12 pts, Recommended)

Build the detector circuit shown. Hook one channel of the scope to the output and the other to the input. Push the AM button on the HP signal generator (blue **Shift** button and then the sine wave button). You should now see an amplitude modulated signal on the oscilloscope, like the one shown in the box. (You may have trouble stabilizing the scope display, try adjusting the trigger controls or



**Amplitude Modulation**

The **A**mplitude of a high frequency sine wave called the *carrier* is ***M**odulated* (varied) by a lower frequency signal. This is the way AM radio and analog TV signals are broadcast. The high frequency is the radio frequency that you tune in, and the lower frequency signal is the audio or video signal that you actually want to receive. AM can also used in *frequency multiplexing* schemes to send multiple signals through one wire.

If you were to vary the frequency of the carrier rather than the amplitude, then you would have ***F**requency **M**odulation* or *FM*.

triggering on the detector output.)

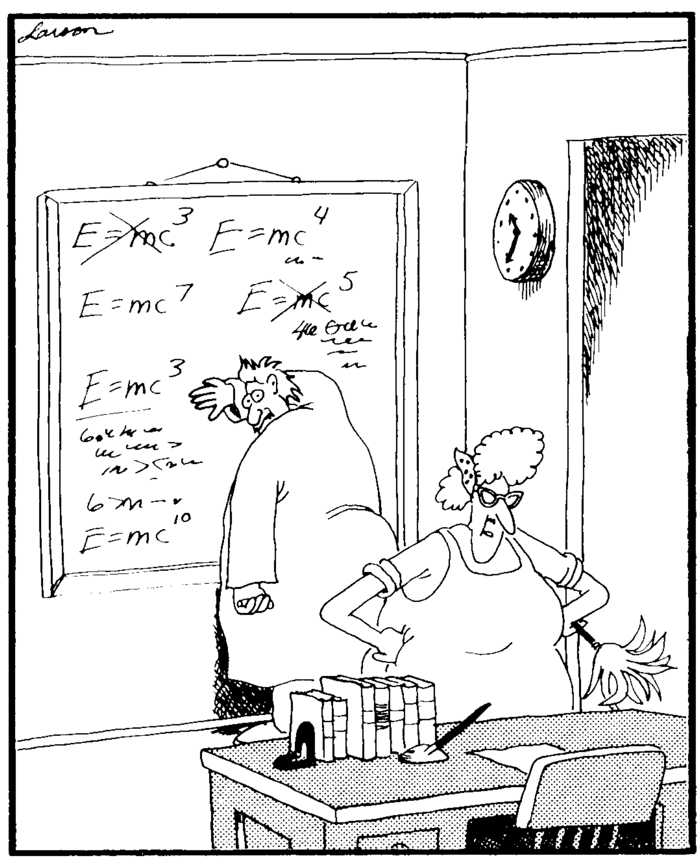
The purpose of a detector is to *detect* the desired signal and separate it from the carrier.

Adjust the AM carrier to 10 kHz and 5 $V_p$ (5 $V_{pp}$ on HP). Use the normal frequency and amplitude buttons on the HP for these adjustments. If you want to adjust the modulation frequency or amplitude (shown as a %), hit the **Shift** button before the frequency and amplitude buttons. (Go ahead and play with these now if you want to, but reset them to 100 Hz and about 100 % when you're done.)

Look at the output of the detector circuit. You should see a somewhat distorted version of the 100 Hz modulating sine wave. (I mean the shape distortion, not the fuzz on top.) Any idea why it's distorted? Add a little DC offset to the HP output and you'll soon see the distortion clear up. Comment in your notebook. This is actually a far more important concept than it first appears to be. Basically we're adding some DC bias to overcome the diode's 0.7 V drop. We'll do a lot of biasing in the future.

Experiment with some different resistors in the detector circuit. In particular, try the 1 kΩ. What happens if R is too small? Try resistors larger than 10 kΩ. Use at least one resistor large enough that the output no longer looks sinusoidal. What happens if R is too big?

**SPICE project # S1** Voltage Doubler
You'll soon start working on the first SPICE assignment, which will be this circuit. Make a copy of the waveform sketches you made for the doubler circuit so that when you get your SPICE output, you can compare your actual circuit results from this lab to those you get with SPICE. You will turn in your copies of the experimental curves with the SPICE assignment.



"*Now* that desk looks better. Everything's squared away, yessir, squaaaaaared away."