EE321 Lab 4 - Power supply

3rd May 2005

1 Purpose

The purpose of this experiment is to study the properties of a simple unregulated power supply.

2 Overview

You need to make voltage and current measurements on a simple power supply using the available equipment.

The first step is to measure the transformer, to understand the turns ratio and equivalent series resistance.

The second step is to use it to build a simple power supply with a half-wave rectifier, and measure properties such as diode voltage and current, capacitor voltage and current, and load voltage and current.

If you have time, rebuilt it with a full wave bridge and measure it again.

After measuring it in the lab, at home you will correlate your measurements with your calculated values.

Since you will be making precision measurements, it is important that all connections must have as low resistance as possible. It is best to build it entirely on the binding posts.

3 Parts and equipment needed

- 1N4001 diode (4 for the bridge).
- 0.1 ohm, 2.2k 1/4 watt resistor, 100 ohm 2watt resistor.
- 1000 uf electrolytic capacitor
- AC line transformer.
- Scope and DVM on the bench.

4 Procedure

Warning

The transformers have an internal fuse that will blow if you short the output. Do not short the output of the transformer. Before plugging it in, have someone else check your wiring.

4.1 The transformer

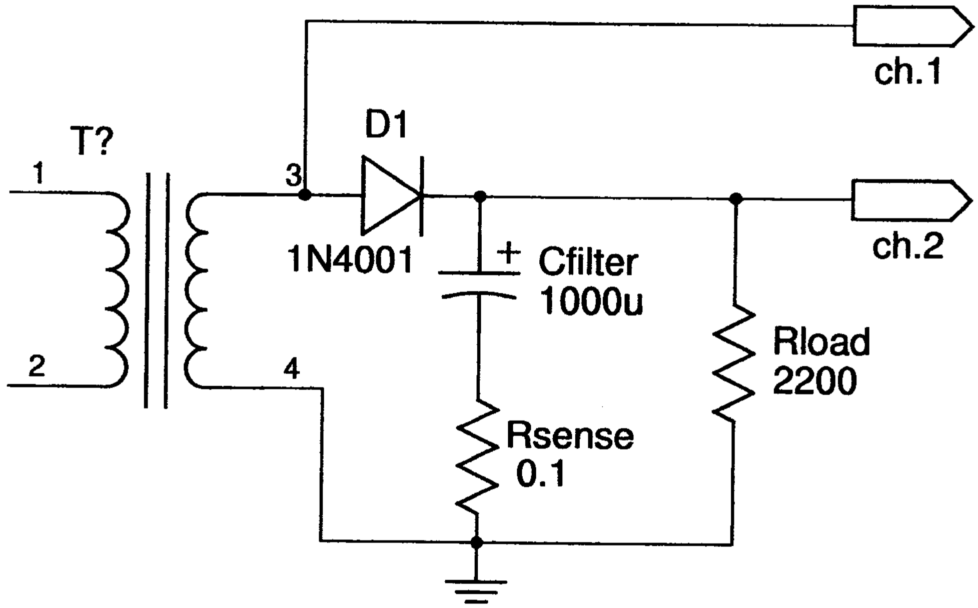
Before building the power supply, you must understand the transformer. You need to determine the turns ratio, AC output voltage, and equivalent series resistance. You can think of it as an ideal transformer with a resistor in series with the secondary.

1. Using the DVM, measure the AC line (primary) voltage. It should be about 120.
2. Plug in the transformer. With no load connected, measure the secondary voltage. It should be about 12. Calculate the turns ratio (primary:secondary). It is the ratio of voltages.

3. Connect a 100 ohm resistor to the secondary. Measure the voltage again. It should drop a little, probably to about 11. Based on this information, calculate the equivalent series resistance inside the transformer. I think it is about 10 ohms.

4.2 Half wave rectifier with filter.

In this step, you will build a simple power supply, using a half wave rectifier and capacitor. Yours will need a small resistor in series with the capacitor so you can measure its current.



1. Build the power supply as in the schematic. Be sure to observe polarity on the capacitor and diode. Be careful not to short the transformer. Build it entirely on the binding posts.
2. Initially set the scope as follows:
   (a) Time base to .01 second/division.
   (b) Both channel 1 and 2 to 5 volts/division, DC coupled, centered, overlaid.
   (c) Trigger from channel 1.
3. Connect the scope, channel 1 to the transformer, channel 2 to the load, both black leads to ground.
4. Apply power, observe, and sketch the waveforms.
5. If the DC is too smooth to see the ripple, switch that channel to AC coupling, and turn up the sensitivity.
6. Fill in the chart, VAC, VDC, peak inverse voltage, and ripple, in the column "2.2K load".
7. Set the scope back to DC coupling, 5 volts/division, change the load to 200 ohms (2 100 ohm 2 watt resistors in series), and repeat steps 4, 5, and 6. Fill in the table under "200 ohm load".
8. Disconnect channel 1 of the scope from the transformer, and connect it across the .1 ohm resistor. Leave it DC coupled.
9. Turn up the sensitivity so you can see a waveform there. You should see large positive spikes, when the capacitor charges, and a small negative residual when the capactor discharges.
10. Sketch the waveform.

11. Measure the pulse width of the positive spike, the peak positive voltage, and the relatively steady negative voltage. You may need to turn up the sensitivity to see it.

12. From these voltages, determine the currents. The negative (discharge) current should equal the load current. The positive (charging) current should be much larger. Why is it so large?

half wave	2.2K load	200 ohm load
VAC, peak		
VDC, max		
VDC, min		
ripple voltage		
peak inverse voltage		
peak charge current	xxxxx	
charge pulse width	xxxxx	
discharge current	xxxxx	

4.3 Full wave bridge.

If you have time, rewire it to a full wave bridge, 4 diodes, and repeat the measurements.

full wave bridge	2.2K load	200 ohm load
VAC, peak		
VDC, max		
VDC, min		
ripple voltage		
peak inverse voltage		
peak charge current	xxxxx	
charge pulse width	xxxxx	
discharge current	xxxxx	

5 Your report

Please include the following sections, in the order indicated.

5.1 Executive summary (on cover)

Show a schematic of your power supply, and provide a chart of the important specifications. Your chart should have 3 data columns: measured, predicted, and simulated.

5.2 More detailed summary

Write a paragraph on what you learned, and point out any surprises.

Compare your measurements to the predictions and simulations. Explain the differences.

If you didn't do the full wave bridge in lab, make calculations to predict how it would perform. Compare it to the half wave circuit.

Assuming you are using the half wave circuit, explain how you can also generate a negative voltage at the same time, so you can power op-amp circuits. Why doesn't this work with the bridge?

5.3 Journal

Provide a journal of what you did, with enough detail that someone else can reproduce your experiment and verify your work.

5.4 Analysis

Provide your manual analysis of your circuit. Even if you only built the half wave circuit, provide the analysis for both full wave bridge and half wave circuits.

5.5 Simulation

Normally you would simulate before building, but this time you can do it after building.

Simulate the half wave rectifier circuit using the diode parameters you determined in last week's report.

Instead of the transformer, use a single AC sinusoidal source, with a series resistor. Then do a "transient" analysis to see the waveforms.

You can make a sinusoidal source for transient analysis like this:

```
Vsource 1 0 sin frequency=60 amplitude=18
```

Of course, you should substitute whatever amplitude you actually measured. Use the peak voltage, not peak-to-peak or RMS.

To see a waveform, you need to do a "transient" analysis. As always, before this you need to set up probes. You need to run it for at least three cycles, preferably more, with at least 20 steps per cycle, prefarably more. Run it for .1 seconds with a step size of 200 microseconds.

Here's my netlist:

```
Vsource ( 1 0) SIN amplitude= 18. frequency= 60.
Rsource ( 1 2) 10.
D1 ( 2 3) mydiode
.model mydiode d (is= 10.f)
Cfilter ( 3 4) 0.001
Rprobe ( 4 0) 0.1
Rload ( 3 0) 200.
```

Now you can run it:

```
print transient v(nodes) I(Cfilter) I(Rload)
tran 0 .1 200u
```

You can get a plot (an ugly one, but still a plot) with the plot command:

```
plot transient I(cfilter)(-.6,.6) V(Rload)(10,14)
tran 0
```

Just saying "tran 0" says to start over, but keep the stop point and step size. The numbers in parenthesis after the name of a probe is the range. It is better to specify the range yourself. The simulator usually picks a stupid range.

Now that you have the idea, you should be able to get a plot of the diode current waveform, the transformer current waveform, and the voltage across the diode. Compare what you simulate to what you measured.