University of Utah
Electrical & Computer Engineering Department
ECE 2100
Experiment No. 6

Power Supply

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rev, 2/18/03

Minimum required points = 58 Grade base, 100% = 82 points
Recommend parts = 78 points (about 95%)

Objectives

1.) Learn about rectification.
2.) See the real effects of filter capacitors and winding resistance.
3.) Use an IC 3-terminal regulator.
4.) Examine a switching power supply.

Check out from stockroom:

- Wire kit
- 10x probes
- Large adjustable power resistor, at least 20 Ω
- two 3300 µF Capacitors
- Switching Power Supply

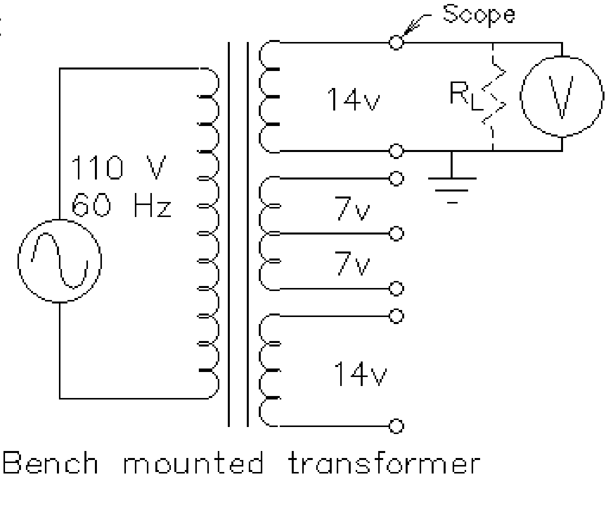
Parts to be supplied by the student:

These items may be bought from stockroom.

- 1 kΩ resistor
- four 1A rectifier diodes (ex. 1N4001, 1N4002, 1N4004) or Bridge Rectifier from last lab
- 3-terminal voltage regulator LM7812T
  You may also use an LM317T adjustable regulator with a 240 Ω resistor and a 5 kΩ pot.

Experiment 1, Basic Power Supplies (53 points, recommended)

Power resistor (load): Examine the large cylindrical power resistor that you checked out. It is basically just a long length of resistance wire or band wrapped around an insulator. The two ends of the wire are connected to terminals at the ends of the cylinder. There is also a slider which makes contact with the wire in between the two ends. If you look, you will find the connection for this slider. Connect an ohmmeter to the slider and one end of the resistor. Adjust the slider until the ohmmeter reads about 20 Ω. Lock the resistor at this value if you can and remember or label the two terminals that you used. This will be your load resistor throughout this lab. This adjustable resistor is just another form of potentiometer. See the box in lab 1 for more on potentiometers.



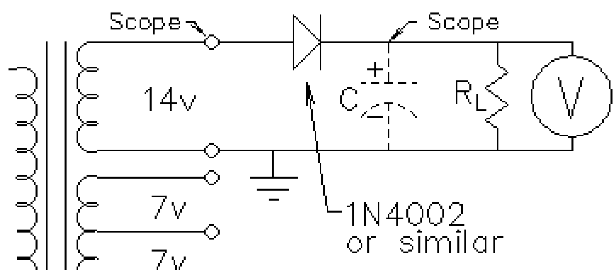
Bench mounted transformer

Transformer measurements: Find the transformer mounted in the bench wire the circuit as shown, but without the load resistor for now. Be sure to connect the scope ground to the transformer.

Observe the waveform on the scope. (If you don't see a waveform, check the transformer fuse.) Comment on its shape in your notebook. Does it look like a sine wave? How about the waveform shown in the power supply handout? Sketch this waveform in your notebook. You may print it out if you want, but a quick sketch is good enough. Measure the peak voltage (V_{pac}) and the approximate width of the flattened top of the waveform (t_{top}). When measuring t_{top}, think in terms of a straight line approximation of the waveform that you see. Add both these values to your sketch.

Use the bench voltmeter to measure the RMS voltage of the secondary (V_{nLrms}). The HP will measure true RMS. Connect the 20 Ω load resistor and measure again (V_{Lrms}). Calculate the winding resistance of this transformer (R_w, see the power supply handout). Other than lowering the voltage, did connecting the load have any significant impact on the waveshape?

Half-Wave Rectifier



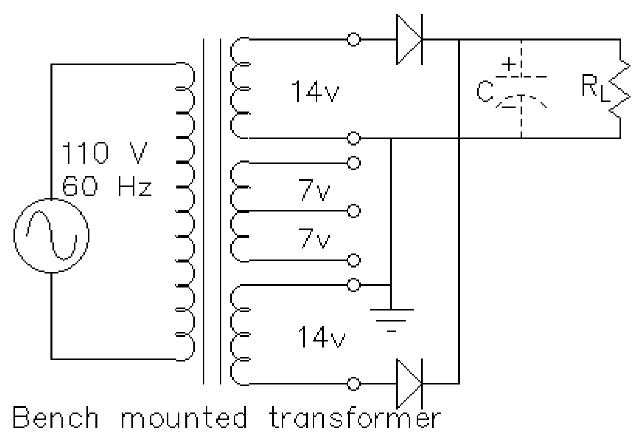
Build the circuit shown at right without the filter capacitor, C. Use a 1 kΩ resistor as R_L (just to make a little current flow through the diode).

Observe the waveform at R_L. Is this what you would expect for a half-wave rectifier? Use the scope to measure the load voltage, both as DC (average) and as AC (peak-to-peak ripple).

Next you'll add the filter capacitor, BUT BE CAREFUL. If you think the small caps you used before pack a punch when they blow, you ain't seen nothin' yet. Be absolutely certain of your polarity **before** you turn on the power and shield your eyes as you do. . Observe the waveform at R_L. Measure the DC load voltage (V_{Lave}), and the peak-to-peak ripple (V_r).

Change the load to the 20 Ω resistor. Measure the DC load voltage (V_{Lave}), and the peak-to-peak ripple (V_r). Calculate the I_L as V_{Lave}/R_L. Remark on the shape of the ripple voltage and the transformer output voltage.

Full-Wave Rectifier



Build the circuit shown at right without the filter capacitor, C. Use a 1 kΩ resistor as R_L. Notice that we're not really using a center-tap transformer here, but rather creating one with the multiple secondary windings of this transformer.

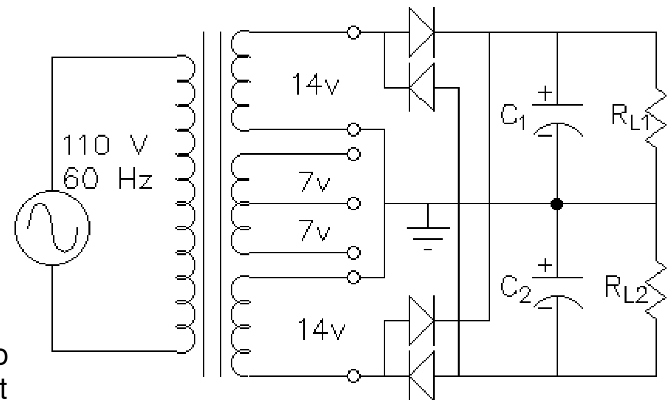
Observe the waveform at R_L. Is this what you would expect for a full-wave rectifier? (If not, check the transformer fuse, then if still not, swap the leads to the bottom winding.) Use the scope to measure the load voltage, both as DC (average) and as AC (peak-to-peak ripple).

Add the filter capacitor. Observe the waveform at R_L. Measure the DC load voltage (V_{Lave}), and the peak-to-peak ripple (V_r).

Change the load to the 20 Ω resistor. Measure the DC load voltage (V_{Lave}), and the peak-to-peak ripple (V_r). Calculate the I_L as V_{Lave}/R_L. Observe the shape of the ripple voltage and the transformer output voltage. Sketch the waveforms in your lab notebook or make a print-out. Notice particularly the non-sinusoidal appearance of the transformer waveform. Try disconnecting and reconnecting the load while you watch the scope. Compare the transformer voltage to Fig. 3.41, p.187, and the ripple voltage to Fig. 3.42, p.190.

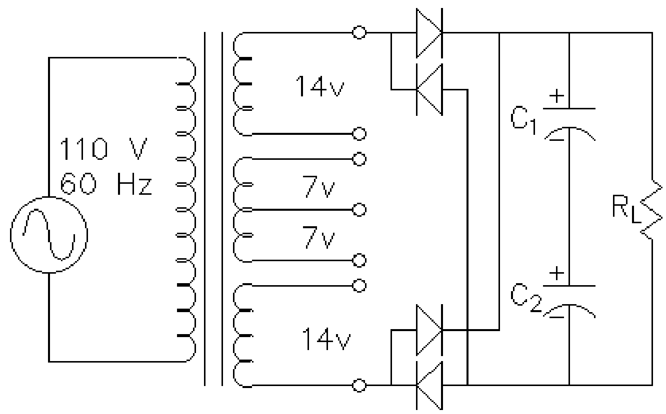
Full-Wave Rectifier, + & -

Look at the circuit at right. Notice that it is a simple logical extension of the circuit that we've already made. Build this circuit and measure the DC voltages. Since you only have one load resistor, just leave the load off.



Bridge Rectifier

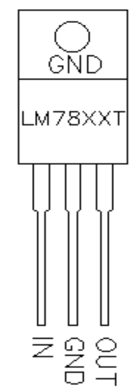
Remove a couple of wires and you get the next circuit, the bridge rectifier. **DO NOT** replace the two capacitors with one. The capacitors you have won't take the voltage. Build this circuit and measure the DC voltage with no load. (If you hook the 20 Ω load to this circuit you may draw too much current.)



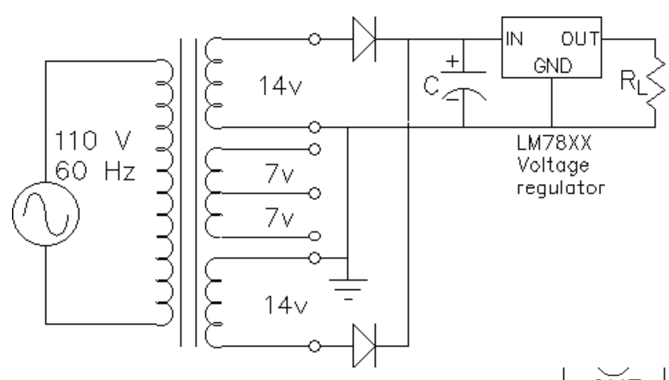
Experiment 2, 3-terminal regulator (15 points, recommended)

Build the circuit shown below. Use either the fixed regulator as shown here, or substitute the adjustable regulator as shown on the next page. Use a 1 kΩ resistor as R_L.

Observe the waveform at R_L. Any trace of ripple left? Measure the DC load voltage. The LM7805T should output 5 V and the LM7812T should output 12 V, ± 2% (± 4% over entire temperature range). Is the output voltage within spec? The LM317T may be adjusted to the voltage any voltage from 1.2 V to within 3 V of its input voltage. Try adjusting it to too high a voltage and see what happens.



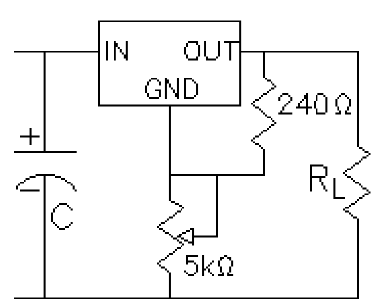
These regulators are designed to deliver up to 1 A. So our 20 Ω load resistor should pose no problem, however, they are also designed to be attached to a heat sink. With no heat sink their power dissipation is limited to about 3 W at room temperature. I want you to hook the 20 Ω load to this circuit, but only for a very short time. Prepare your scope and voltmeter to measure the ripple voltage and DC voltage at the load and make your connection. Watch out for a hot regulator.

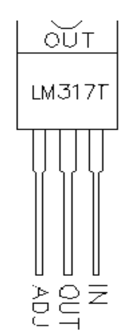


Oscillation problems?

Add a 0.1μF capacitor from the regulator input to ground and a 1μF capacitor from its output to ground.

Comment in your lab notebook on the apparent usefulness of these regulators, about their abilities to reject ripple, and their regulation.





Experiment 3, Calculations (10 points, recommended)

These calculations may be made later.

Calculate an r_d for the diode. (Don't use the r_d you may have found in the last lab, that data was taken at a far lower current.)

You measured a DC voltage (V_{Lave}) and a ripple voltage (V_r) for the full-wave rectifier circuit with the filter capacitor and the 20 Ω load. You also calculated an I_L from the V_{Lave}. Now, using your transformer measurements, and my handout on power supply calculations, Calculate the expected V_{Lave} for this I_L and this circuit. Conclude by comparing your calculations to the measurements made in this lab.

Experiment 4, Switching Power Supply (15 points)

DO NOT PLUG THIS SUPPLY INTO WALL POWER. In order to safety use the measuring instruments in the lab with this supply plugged in, you would need to an "isolation transformer" between the wall outlet and the power supply. An isolation transformer is a 1 to 1 transformer who's sole purpose is to make sure that whatever is plugged into it is not "hot" with respect to bench ground. This, oddly enough, is called "isolation". Without this isolation you could seriously damage the circuit if you hooked the scope's ground to the wrong place. Or, even worse, you could seriously damage yourself if you touched the wrong place in the circuit as well as any metal part of the bench.

Most commercially made power supplies are now made as "Switching" power supplies. Essentially, they rectify the full line voltage and by "switching", make it into higher frequency power which they then run through a much smaller transformer. The electronics are cheaper then a big transformer.

Examine the switching power supply that you checked out. Notice on the printed circuit side of the board that the 110 VAC, high-voltage side of the board is completely separated from the low-voltage side. This separation is only bridged by two parts, the transformer, and an "opto-isolator" (a part in which there is an IR transmitter and an IR receiver and no electrical connection between the two sides).

Turn the board over to see the parts. Make a sketch in your notebook and try to identify the following parts on your sketch.

1.) Fuse
2.) A group of parts near the input plug used for line filtering and surge protection
3.) Bridge rectifier for the high voltage
4.) Filter capacitor for the high voltage
5.) Switching transistor (Q1 attached to heat sink)
6.) Transformer
7.) Opto-isolator
8.) Low-voltage diodes (two in one package, also on heat sink)
9.) Zener diode (DZ1)
10.) Low-voltage filter capacitors