Homework #6 (Adjustable Power Supply with Current Limit) Due 10/10/07

Design a linear power supply that will output +**7V and is <u>current limited</u> to 200mA**. The input to the supply will be a **120VAC (i.e. wall socket)**. Use LM317 adjustable voltage regulators to limit the maximum output current to 200mA and to regulate the output voltage. Note: You'll need two LM317s (one for the current limit and one for the voltage regulator).

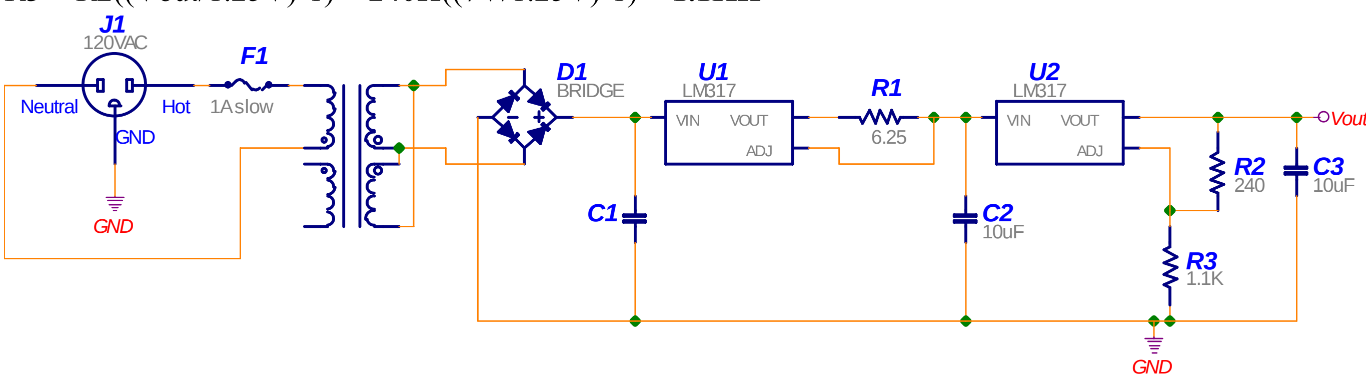
Provide a digikey part # for the transformer and rectifier. Calculate the ripple voltage on the filter cap and show there is sufficient headroom for the voltage regulator and current limit to operate. Don't forget about the rectifier voltage drop, ripple voltage on the filter cap, headroom on the LM317 (about 2V), the voltage across the current limit resistor (about 1.25V), and a safety margin.

Draw a complete schematic and label the voltages at the input to both LM317s when the output current is less than 200mA (i.e. the current limit isn't limiting the current).

Don't worry about calculating the regulators temperature rise or heatsink requirements on this homework.

Solution:

Between the bridge rectifier and the voltage regulator we will put a current limit circuit using the LM317. The voltage drop between the output and the adjust pin on the LM317 is 1.25V so to limit the current to 200mA the current limit resistor (R1 in the schematic) needs to be 1.25V/200mA = **6.25Ω**. To set the output voltage the following equation is used: Vout = 1.25V(1+R3/R2) + IadjR3, note: we assume Iadj is much less than the 5mA through R2 so we dropped the Iadj term in the above equation. We'll use a 240Ω resistor for R2 (as recommended by the datasheet). For Vout=7V we need to calculate R3:
R3 = R2((Vout/1.25V)-1) = 240Ω((7V/1.25V)-1) = **1.1KΩ**



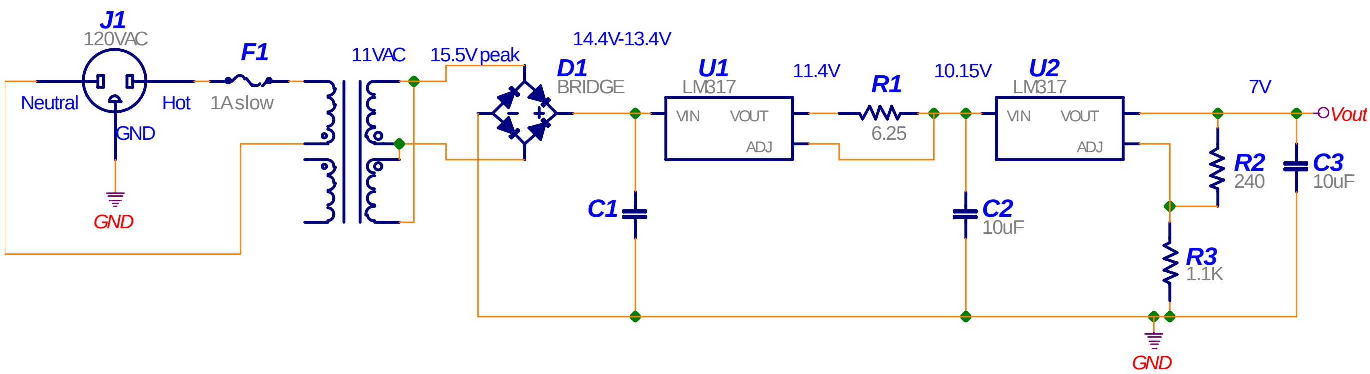
To calculate the size of the needed transformer we'll add up all the voltage drops from the output back to the transformer. 7V output + 2V dropout for the adjustable regulator + 1.25V drop across the 6.25Ω current limiting resistor + 2V dropout for the LM317 used in the current limit + say 1V ripple on C1 + say 1.5V for the bridge rectifier = 7V+2V+1.25V+2V+1V+1.5V = 14.75V. We'll add a little for a safety margin, say 15.5V peak = **11V rms**. Add a little to the current for a safety margin, say **250mA** total.

We need a transformer with a 120VAC input and >11V@>250mA output. Digikey lists the following transformer: **SB3516-3022 (MT7276)**. It puts out **11VAC@270mA** with the outputs in parallel. Note: It doesn't have dual primary windings as shown in the schematic. I didn't have the proper library part.

The bridge rectifier was chosen the same as in homework #5 (**DF01M**. rated at 1.5A with a max reverse voltage of 100V). This bridge drops **1.1V** total across both diodes at 1A of current.

C1 needs to be large enough to limit the ripple current to 1V when the load draws 200mA.
C = IT/V = (0.2A*8.33ms)/1V = 1,670uF. We'll use **2000uF** to be safe. Note: the capacitors voltage rating should be higher than the peak voltage (in this case 11Vrms = 15.5V peak). Use a cap rated at 20V or 25V for safety.

Labeling all the voltages when I = 200mA (i.e. the current limit doesn't kick in and drop the input voltage to the voltage regulator).
$V_{transformer}$ = 11Vrms = 15.5V peak
V_{C1} = 15.5V – 1.1V = 14.4V (transformer voltage minus the drop across the bridge rectifier)
V_{C1} could drop another volt due to the ripple making the V_{C1} = 13.4V
$V_{out(U1)}$ = 13.4V – 2V = 11.4V (output of bridge minus headroom for current limit LM317)
$V_{in(U2)}$ = 11.4V – 1.25V = 10.15V (current limit output minus 1.25V drop across R1)
$V_{out(U2)}$ = 7V (since the minimum input (10.15V) is greater than the 9V required it will regulate to 7V).



Note: If I < 200mA then the voltage drop across R1 will be less than 1.25V. With no load there won't be any drop across R1. R1 will always have some current flowing through it since R2 & R3 draw about 5mA independent of the load attached to Vout.