PreLab 2 – AC-to-DC Power Supplies (Week of Apr 13)

• GOAL

The overall goal of PreLab2 is to simulate some circuits that are useful for making a DC power supply.

• GENERAL GUIDELINES

1) Each student must turn in his/her own Pre-Lab assignment (include both schematics and waveforms).

2) Students are allowed (even encouraged) to work together. However, you must turn in your own work!

3) SAVE ALL SCHEMATIC AND WAVEFORM FILES – you will need them for your lab report.

• PART 1: FULL-WAVE RECTIFIER

The full-wave rectifier uses two diodes to rectify both positive and negative portions of the input AC signal. The AC signal usually comes from a power transformer, where the 120 V_{RMS} wall plug is stepped down. In lab, we will use a "28 VCT" transformer, which means the secondary voltage is 28 V_{RMS}. The "CT" means a center tap connection is available.

TASK 1a: Simulate the full-wave rectifier in Fig. 1.

- Use the transformer model TS_PQ4_12 in Multisim. The transformer secondary voltage is 26 V_{rms} rather than 28 V_{rms} but it is close enough.
- The diodes are 1N4002 and the load resistor is 10 kohm.
- Run your simulation and use the cursors to measure the maximum voltage and add a label to your graph.
- Print out both the schematic and graph.
- You can change the text displayed at the top of the graph by selecting EDIT from the graph window and selecting Page properties. Change these to something more meaningful than the default.
- Turn in both the schematic and the waveform. You can copy both the schematic and graph and insert both the schematic and waveform in a Word document. Both figures can be placed side by side by shrinking their widths to about 2.5 inches. To copy the graph single right click on the graph and select copy graph.

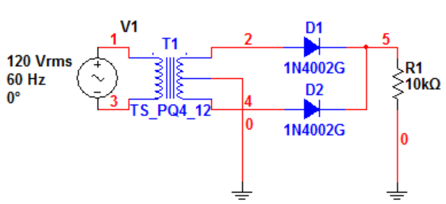

Fig. 1: Full-wave rectifier schematic.

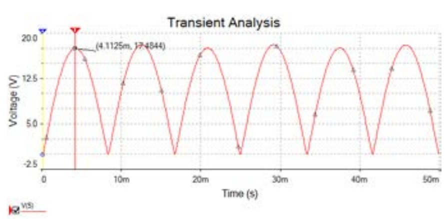

Fig. 2: Your load voltage should look like this.

TASK 1b: Now add a 10 uF capacitor, as shown in Fig. 3.

- Use the same time settings as Task 1a.
- Measure ripple voltage using the cursers. From the transient analysis output menu add an expression to calculate the mean and run the transient analysis again. Make sure the left axis starts at 0 V.
- Compute the "ripple factor", which is defined as RIPPLE FACTOR = V_{RIPPLE} / V_{MEAN}.
- Submit the schematic, two waveforms, and ripple factor.

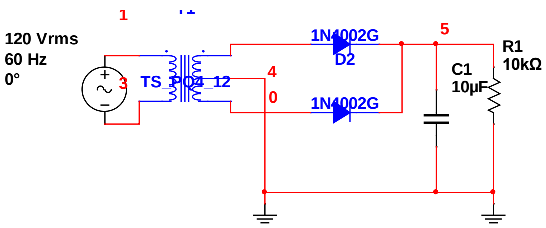

Fig. 3: Full-wave rectifier with 10 uF filter capacitor.

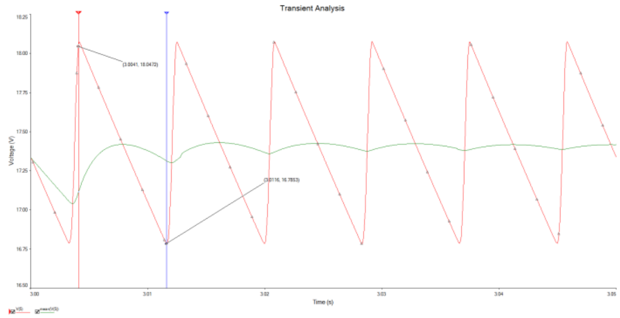

Fig. 4: Your waveform graph should look like this.

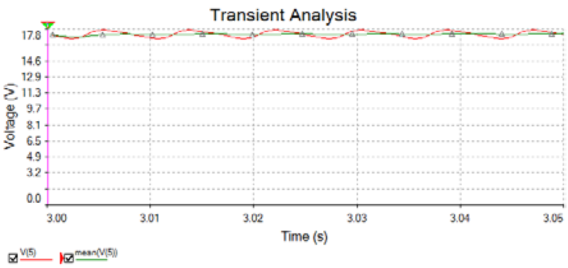

Fig. 5A: Your waveform graph should look like this.

PART 2: ZENER REGULATOR

Zener diodes produce a relatively fixed output voltage. They are better suited for low power applications such as voltage references. Higher power applications (e.g. power supplies) require additional transistors to boost the output current and provide feedback to maintain the desired output voltage. We'll start discussing transistors in a couple of weeks!

TASK 2: Simulate the zener regulator shown in Fig. 5.

- Use the same AC voltage source as Part 1 (two 20 V_P, 60 Hz sine wave generators with ground connection).
- The circuit uses 1N4002 diodes, a 10 uF electrolytic capacitor, 750 ohm resistor, two 1N4734A zeners, and a 10 kohm load.
- Use the same simulation time settings as Part 1 (T_{STOP} = 100 ms, max dt = 50 us, start data output = 50 ms).
- Measure the mean and peak-to-peak voltages at the load.
- Add a legend box to your waveform graph.
- Compute the ripple factor.
- Submit the schematic, waveform, and ripple factor.

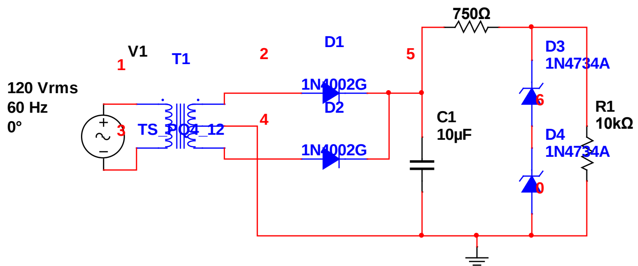

Fig. 6: Zener regulator using a full-wave rectifier as input.

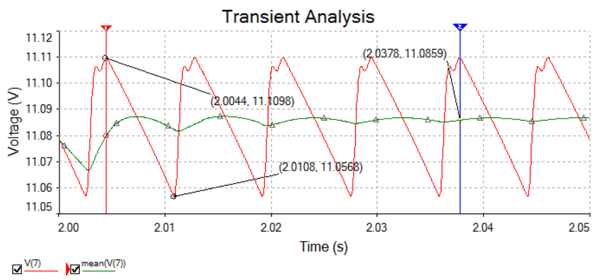

Fig. 7: Your load voltage waveform should look like this.

(see next page for Part 3)

PART 3: ADJUSTABLE POWER SUPPLY

A high quality power supply is really a "voltage regulator". This means the output voltage is stabilized to a specific value. The LM317 is a convenient chip that does this for you! The input to the chip is an unregulated voltage, such as from a full-wave rectifier. The LM317 contains a zener diode for voltage reference and lots of transistors to boost the output current and stabilize the output voltage. The LM317 has the additional benefit of letting you easily adjust the output voltage. Nice!

TASK 3: Simulate the adjustable power supply shown in Fig. 7.

- Use the same transformer and source as before.
- The full-wave rectifier uses two 1N4002 diodes and a 470 uF electrolytic capacitor.
- The LM317 can be found by going to **Place Power Voltage Regulators**. Multisim has a model for the LM117 family which will work. You will find a working circuit file on the WEB site called PreLab2Task3.ms11 which includes a model for the LM317. This model can be copied to other circuits.
- It takes a long time for the 470 uF capacitor to charge so you should start displaying data to the graph at 5 seconds. Figure 9 on page 5 shows the transient values. It takes at least 10 s to run the simulation.
- The LM317 needs some extra parts (1.2 kohm resistor and 10 kohm potentiometer) to work properly.
- The 10 kohm potentiometer (adjustable resistor) can be found by going to **Place>>Passive>>Potentiometer**.
- Double-click on the 10k pot and set the "Wiper" position to 1.0. This means the pot is set to 10 kohm.
- The 1 uF electrolytic capacitor helps produce a cleaner output.
- The load is a 1 kohm resistor (at the end of lab, you will replace this with a 12V DC motor).
- Use the same simulation time settings as Part 1 (T_{STOP} = 100 ms, max dt = 50 us, start data output = 50 ms).
- Measure the mean and peak-to-peak voltages at the load.
- Add a legend box to your waveform graph.
- Compute the ripple factor – it should be really tiny, which is good!
- Submit the schematic, waveform, and ripple factor.

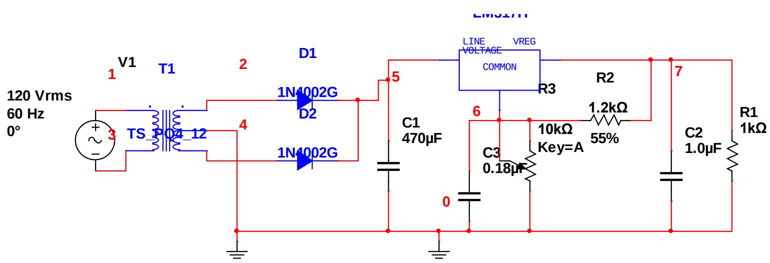

Fig. 7: Adjustable power supply using a LM317 chip.

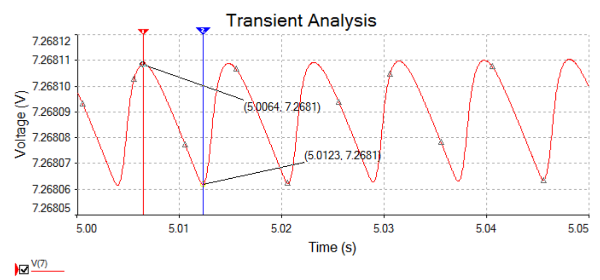

Fig. 8: Your voltage waveform should look like this.

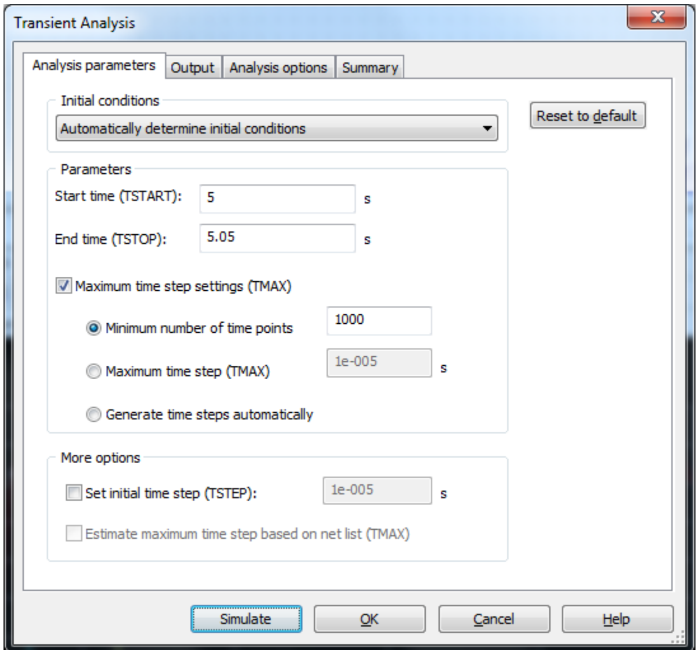

Figure 9

(End of PreLab2)

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