EE 3310L/5310L · Electronic Devices and Circuits Laboratory

Lab 3: Linear Power Supply with Zener Regulation

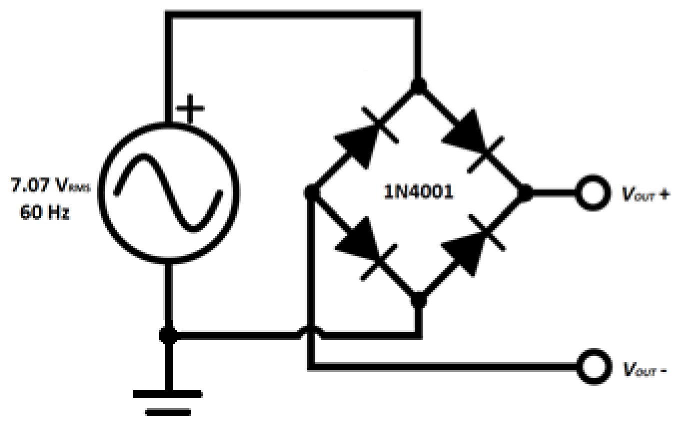
Purpose

The purpose of this lab is to build and test a linear power supply with a Zener-diode voltage regulator circuit. Although linear power supplies operating at 50 or 60 Hz have largely been replaced by high-frequency switching supplies that are small, lightweight, and efficient, linear power supplies are still used in many applications and tend to be quiet, robust, and cost-effective.

We usually think of power supplies as starting from a 120- or 240-V AC outlet; then the voltage is transformed, rectified, smoothed/filtered, regulated, and connected to the final load. Since design and construction errors can often have catastrophic consequences whenever line voltages are involved, we'll build a much smaller-scale power supply using our function generator as a 60-Hz source with correspondingly smaller voltages and currents.

Procedure

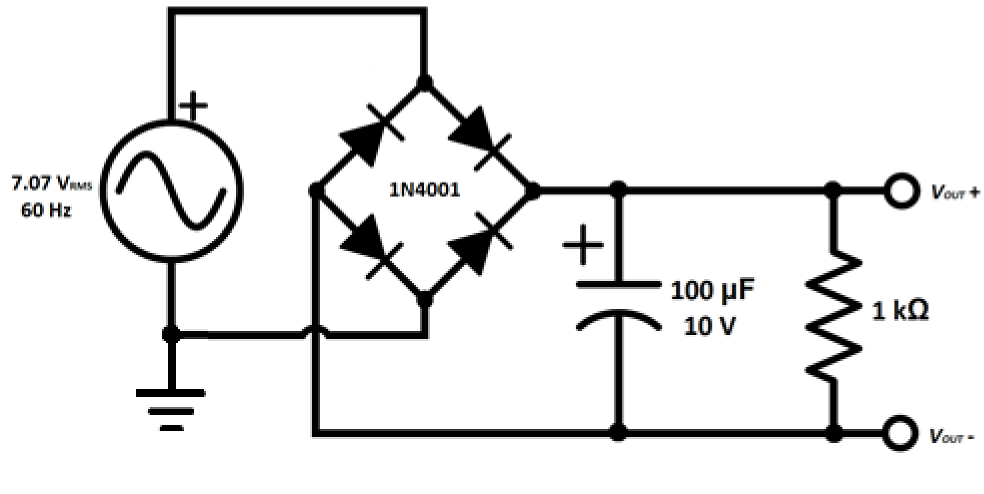
1) Set the function generator to produce a 7.07-V_{RMS} (20-V_{P-P}), 60-Hz sinusoid. Connect it to a full-wave bridge rectifier circuit using 1N4001 diodes as shown below; pay very close attention to the polarities of the diodes:



Since the function generator is a common-ground instrument, it is not possible to view the output directly with a common-ground (unbalanced) oscilloscope, because grounding the negative output of the rectifier would short-circuit one of the diodes. We need to use both channels of the oscilloscope in *differential mode* to achieve a true floating voltage measurement. [Incidentally, if we had used a power transformer, this wouldn't be necessary; the primary and secondary windings are galvanically isolated from each other, an often-essential feature.] To do so, connect both common (black) leads of the oscilloscope probes to the same common ground as the function generator; then connect the Channel 1 probe to V_{OUT}+ and the Channel 2 probe to V_{OUT}−, as indicated on the bridge rectifier schematic above. Finally, put the oscilloscope channels in differential mode and view the waveform. [On the Agilent 54622A digital storage oscilloscope, simply press the "Math" button located between the two channel buttons, and select "1–2." You will want to then turn off the individual channel yes, 10.4V,

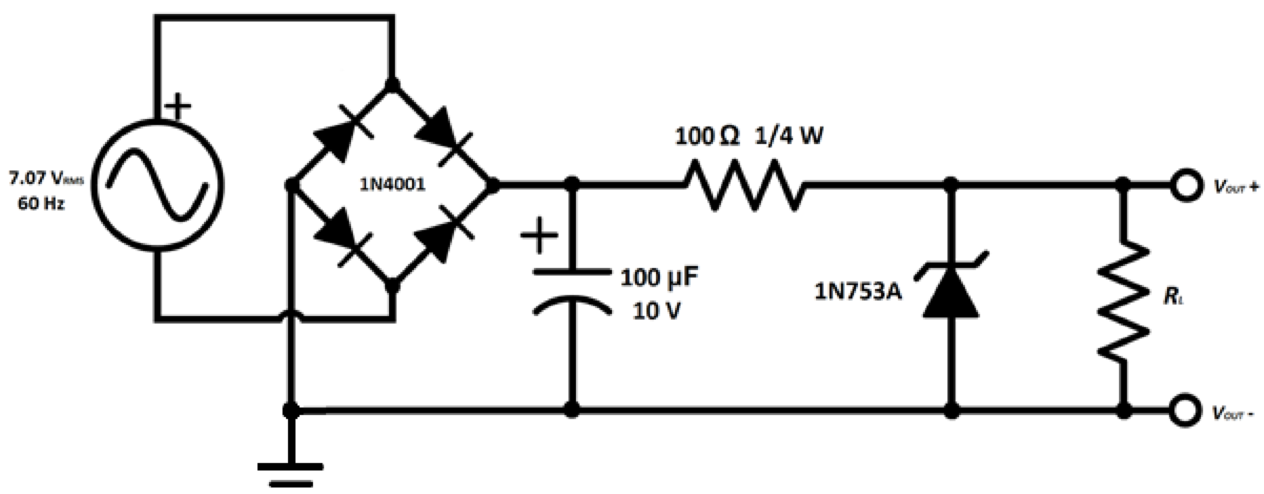
signals.] **Does the observed waveform resemble a full-wave-rectified sine wave? Measure the peak amplitude; is it close to the theoretical value for a silicon bridge rectifier of $V_{PEAK} - 2V_D$?**

2) Now connect a 100-µF smoothing/filter capacitor with at least a 10-V rating in parallel with the output of the bridge rectifier, as well as a 1-kΩ load resistor, as shown. The capacitor will likely be an electrolytic type; make sure it is installed with the correct polarity, as indicated.



The resulting oscillogram should indicate that the rectified pulses have been smoothed into an almost-DC voltage with a sawtooth ripple waveform. **Measure the average DC voltage with the digital multimeter, and measure the peak-to-peak ripple voltage using the oscilloscope. Is the ripple voltage close to the theoretical value of $I_L/2fC$?** Estimate I_L from the measured average DC output voltage divided by the 1-kΩ resistance.

3) Finally, connect a regulator circuit using a 1N753A 6.2-V Zener diode as shown; again, pay close attention to the polarity of the diode:



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The purpose of the voltage regulator is to reduce ripple and hold the output voltage steady for a variety of load currents and line voltages. **Measure the average DC voltage with the digital multimeter and the peak-to-peak ripple voltage on the oscilloscope for a variety of load resistances; fill in the following table.**

R_L (Ω)	V_{RIPPLE} (V_{P-P})	$V_{OUT(DC)}$ (V)	I_L (mA)
∞	0.800	6.01	0
100k	0.800	6.01	0.0561
47k	0.800	6.01	0.119
22k	0.800	6.01	0.225
10k	0.800	6.01	0.561
4.7k	0.800	6.01	1.191
2.2k	0.800	6.00	2.527
1k	0.800	5.96	4.980
470	0.800	5.38	10.404
220	0.800	5.29	15.682
100	1.6	2.45	16.500

At what load current (I_L) does the voltage regulator begin to drop out of regulation? 4.980mA

Finally, with R_L = 1 kΩ, slowly reduce the voltage at the function generator while observing the DC output voltage until the regulator drops out; **record the input voltage at the threshold of drop-out.**

19.1V

Postlab

Plot $V_{OUT(DC)}$ *vs.* I_L using a logarithmic scale for I_L. Circle the region on the plot where the voltage regulator is not effective at holding the output voltage steady with changing load current.

Include all measurements and answer all inline questions in your lab report.