ECE 311 - Fundamentals of Electronics Lab
Design of a 15V-Voltage Regulator

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Title: Design of a 15V Voltage Regulator
Objective: Design and test a 15V voltage regulator.

Preliminary: (Due at the beginning of the next laboratory period)
Consider a positive voltage regulator depicted in Figure 1. Z1 is a 1N5231B 5.1V zener diode and the op-amp is an LM348. Treat the op-amp as ideal.

1) Design the regulator to meet the following specifications/constraints:
   (a) Vout ≈ 15V.
   (b) RL = 1kΩ
   (c) I_{Z1} = 15mA
   (d) IR1, IR2 ≤ 1mA

All resistances must be 5% tolerance standard values.

2) Derive the LR expression and using the values found in Part 1, calculate the value for LR. Hint: You'll have to use a small-signal equivalent circuit. The small-signal model for the ideal op-amp is simply an ideal op-amp.

3) Derive the LdR expression and using the values found in Part 1, calculate the value for LdR.

4) Simulate your design using an ideal op-amp model and a suitable model for the zener diode. (Use Vzo in series with Rz from Lab 9 for your zener model). Verify the calculated LR and LdR values found in Parts 2 and 3 using VS = 20 ± 2V for LR and RL = 1kΩ and RL = 10kΩ for LdR in the simulation. Verify by calculating the %error.

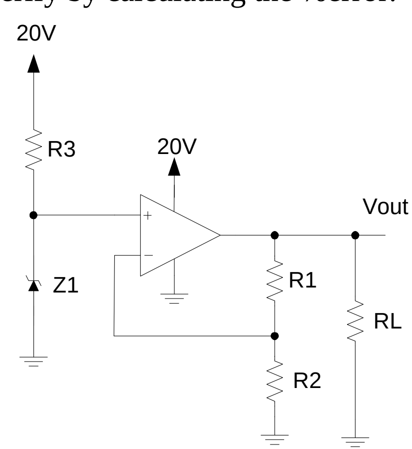

Figure 1 A positive voltage regulator

Laboratory Procedure:

- Use 3 significant digits for all values (measured and calculated)
- Calculate the %Error for all comparisons.

1) Measure and record in the lab notebook:
   a) Resistors R1, R2, and R3 found for Figure 1 in the preliminary.
   b) The load resistance RL=1kΩ (ideal).
   c) A second load resistance RL = 10 kΩ (ideal) for Step 5.
   d) The DC supply voltage (ideally 20V).

2) Construct the circuit given in Figure 1 using the measured resistors and 1 – LM348, Quad LM741 operational amplifier and 1 – 1N5231B, 5.1 Zener Diode.

3) Calculate, measure and compare the operational amplifiers voltage gain:
   a) Using the measured resistance values R1 and R2 calculate the op-amps voltage gain.
   b) Measure and record the zener voltage.
   c) Measure and record Vout and calculate the voltage gain of the op-amp. Compare the measured to the calculated voltage gain found in Step 3a.

4) Line Regulation (LR):
   a) Remove RL.
   b) Reduce the DC supply voltage from 20V to 18V. Measure and record the DC supply and Vout values.
   c) Increase the DC supply voltage from 18V to 22V. Measure and record the DC supply voltage and Vout values.
   d) Calculate LR for the positive voltage regulator. Compare the measured LR to the LR calculated in the preliminary.

5) Load Regulation (LdR):
   a) Return the supply voltage to 20V and load the op-amp with 10kΩ load resistance.
   b) Measure and record Vout.
   c) Calculate LdR using Vout with RL=10kΩ from Step 5.b and RL=1kΩ from Step 5.c.
   d) Compare the measured LdR with the LdR calculated in the preliminary.

6) Positive voltage regulator with full-wave peak rectifier generating the supply voltage.
   a) Construct the full-wave bridge rectifier using a 10μF filter capacitance (C1) as shown in Figure 2 on the following page.
   b) Set the oscilloscope to use line triggering, view the DC supply voltage across C1 (DC coupling), and measure the ripple voltage Vr. Sketch the supply voltage in the lab notebook.
   c) Move the oscilloscope probe to the op-amps output and sketch Vout in your lab notebook.
   d) Does the positive regulator with the full-wave peak rectifier produce a clean DC output voltage?

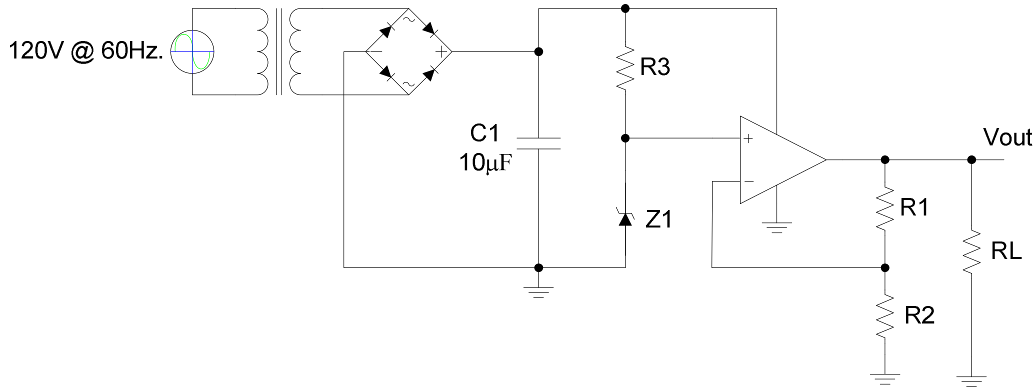

Figure 2: Positive voltage regulator with full-wave peak rectifier supply generation