

Homework Assignment #5 – due via Moodle at 11:59 pm on Tuesday, Oct. 20, 2026

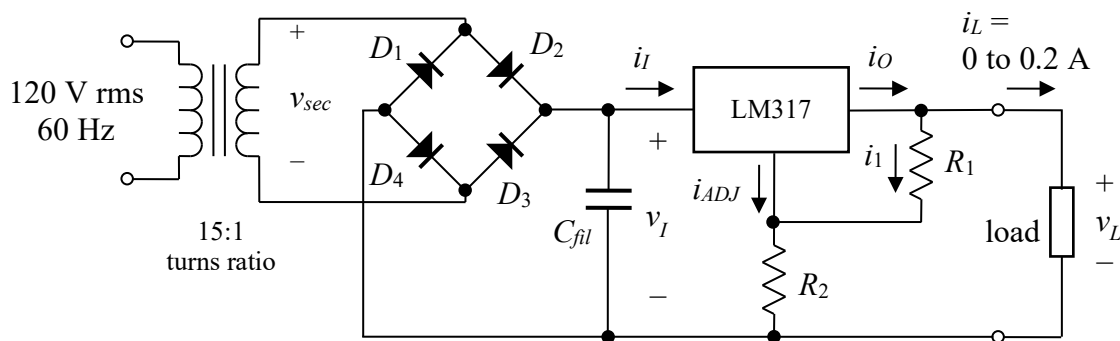
Instructions, notes, and hints:

You may make reasonable assumptions and approximations to compensate for missing information, if any. Provide the details of all solutions, including important intermediate steps. You will not receive credit if you do not show your work.

The first few problems will be graded and the rest will not be graded. Only the graded problems must be submitted by the deadline above. Do not submit the ungraded problems.

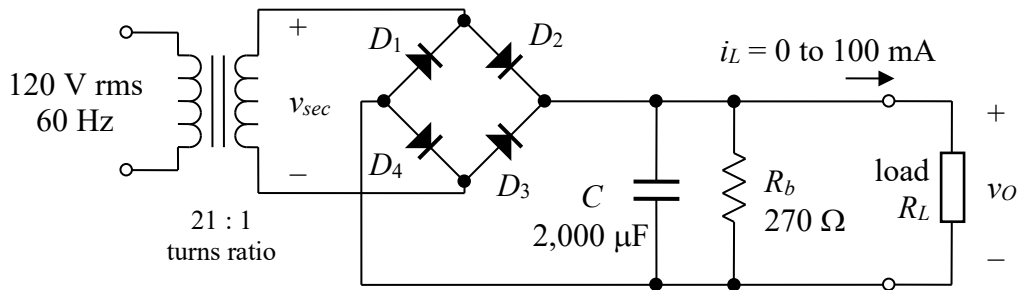
Graded Problems:

1. As shown below, an LM317 voltage regulator will be used in a power supply circuit that includes a full-wave bridge rectifier and a filter capacitor C_{fil} . The rectifier diodes each have a turn-on voltage of $V_F = 1.0$ V, and the transformer's specified secondary winding voltage is 8.0 V rms. The nominal output (load) voltage v_L is to be 3.3 V, and the largest expected load current is 200 mA. The drop-out voltage V_{DO} of the regulator is about 2 V. A datasheet for the LM117 and LM317 is available on the Laboratory page at the ECEG 350 course web site.
 - a. Find the closest standard values in the E24 (5% tolerance) series for resistors R_1 and R_2 to produce a nominal output (load) voltage of 3.3 V while ensuring that the output current i_O of the regulator will be at least 10 mA under no-load ($i_L = 0$) conditions.
 - b. By KCL, $i_I = i_{ADJ} + i_1 + i_L$. Find the required minimum value of capacitor C_{fil} so that the minimum voltage V_{min} across the capacitor is roughly 50% greater than the value necessary to prevent the drop-out of the regulator.
 - c. Find the approximate time-average power dissipation of the LM317 at full output current ($i_L = 200$ mA).

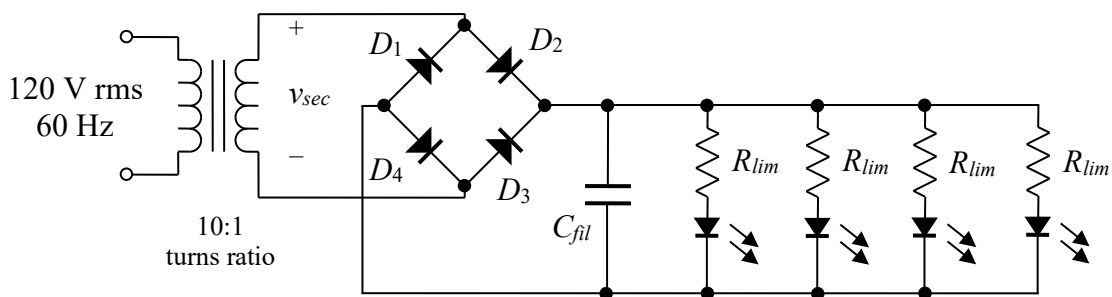


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2. The peak secondary winding voltage in the power supply circuit shown below is approximately 8.1 V. The rectifier diodes each have a turn-on voltage of 1.0 V and a maximum PIV (peak inverse voltage) or PRV (peak reverse voltage) rating of 100 V. The load draws a variable amount of current that can range from zero to 100 mA. Bleeder resistor R_b ensures that the filter capacitor discharges quickly when the power is shut off even if no load is present (i.e., if $R_L \rightarrow \infty$). A bleeder resistor is a safety feature included in most power supplies. Find the worst-case percentage ripple (relative to the peak voltage) on the output voltage v_O for the component values shown. Also find the percentage of the AC waveform's period T during which any one of the rectifier's diodes conducts.



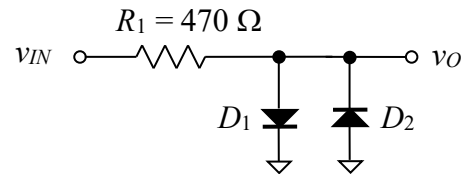
3. As shown below, four white LEDs are to be driven by a simple power supply. (The circuit will serve as a desk lamp.) The designers would like each LED to be supplied with a DC current of around 20 mA. At that current, the forward voltage drop across each LED should be around 3.5 V. The only available transformer has a 10:1 turns ratio. The rectifier diodes have a forward voltage drop of roughly 1.0 V when they are conducting. Find the required values of the filter capacitor C_{fil} and each of the four current-limiting resistors R_{lim} so that each LED has roughly the desired forward current and so that the voltage across the filter capacitor has no more than 5% ripple. The resistors must have a standard value chosen from the E24 (5% tolerance) series. Use the constant-voltage model for the diodes.



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4. Find the node voltage v_O in the diagram below for the three indicated values of the input voltage v_{IN} . Also indicate which (if any) diode(s) is/are on and which is/are off and why. The node labeled v_{IN} is connected to the positive terminal of an ideal voltage source that represents a DC signal source. The source's negative terminal is connected to ground; thus, current can flow into and out of that node. Assume that the constant-voltage diode model with a turn-on voltage of $V_F = 0.7$ V applies and that any external circuitry connected to the v_O terminal draws negligible current.

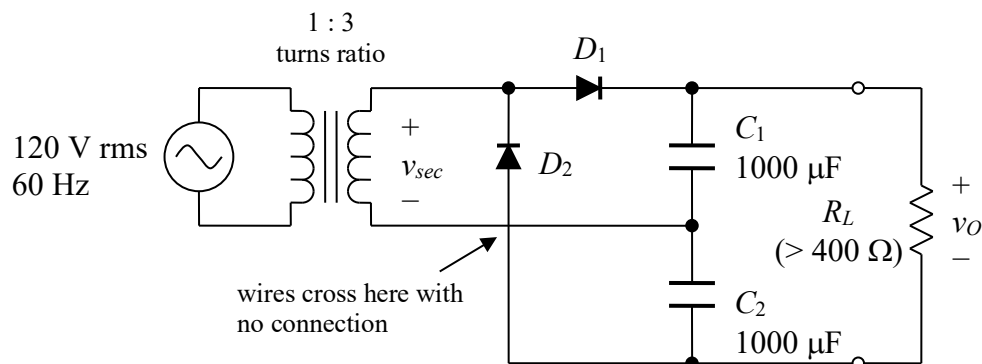
- a. $v_{IN} = 4.0$ V
- b. $v_{IN} = -0.5$ V
- c. $v_{IN} = -2.0$ V



Ungraded Problems:

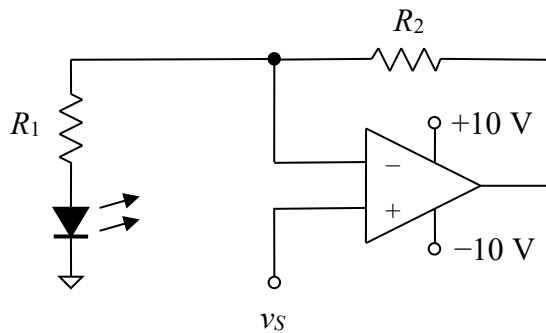
The following problems will not be graded, but you should attempt to solve them on your own and then check the solutions. Do not give up too quickly if you struggle with one or more of them. Move on to a different problem and then come back to the difficult one after a few hours.

1. The power supply circuit shown below is typical of those used to drive high-voltage circuits. Note that it uses a step-up transformer. Also note that the output voltage v_O is the sum of the two capacitor voltages. The load has a minimum equivalent resistance of $400\ \Omega$, but it could be higher. (R_{Lmin} is associated with the maximum possible load current. Smaller load currents correspond to larger equivalent load resistances.) Complete the following analysis steps:
- a. Find the peak value of the secondary voltage v_{sec} of the transformer.
 - b. Find the peak voltages across capacitors C_1 and C_2 if D_1 and D_2 are silicon diodes with turn-on voltages that are negligible compared to the secondary voltage.
 - c. Find the approximate nominal output voltage v_O if the ripple voltage is negligibly small. *Hint:* This circuit called a *voltage doubler*, but you must show/explain why.
 - d. Find the worst-case ripple voltage at the output (across the load R_L). The diodes conduct for only a tiny fraction of each period of the secondary voltage.
 - e. Find the peak reverse-bias voltage experienced by each diode, assuming in this case that the voltages across C_1 and C_2 have negligible ripple.



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2. The circuit shown below is designed to light the LED when voltage v_S (“S” subscript for “sense”) is above the turn-on voltage of the LED, which is $V_F = 1.8$ V. The LED shines brighter as v_S rises. However, above a certain value of v_S the LED stops increasing in brightness as v_S continues to rise. Assuming that the constant-voltage model applies for the LED, find the standard 5% values of R_1 and R_2 that would cause the LED to reach its maximum brightness at around $v_S = 5.0$ V and so that the maximum current through the LED is around 25 mA. The op-amp has the specifications given next to the figure. *Hint:* Aspects of the problem that do not have a significant impact on the determination of the resistor values can be ignored.



Op-Amp:
 max. input offset voltage magnitude: 8.0 mV
 max. input bias current: 100 nA
 typ. open-loop voltage gain: 1.5×10^5
 output voltage limits: ± 9.0 V
 output current limit: 35 mA