

Homework Assignment #6 – due via Moodle at 11:59 pm on Monday, Oct. 26, 2026
[Graded Prob. 4 revised 10/25/26]

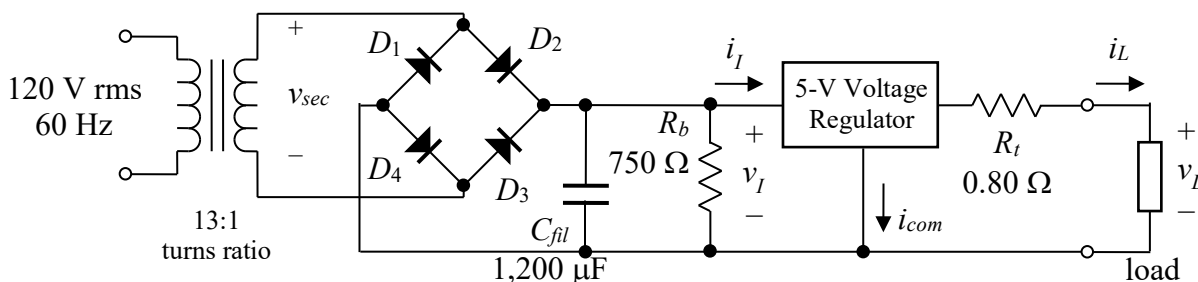
Instructions, notes, and hints:

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. In the power supply circuit shown below, a fixed three-terminal regulator provides a nominal voltage of 5.0 V to an amplifier module. Because of poor design technique, the circuit board trace between the output terminal of the regulator and the positive power supply terminal (the circle near the positive side of v_L) is too thin and has an equivalent resistance of $0.80\ \Omega$. It is modeled as R_t in the diagram. The regulator itself has a specified load regulation of $0.0080\ \text{mV/mA}$. Find the load regulation of the entire power supply circuit, including the effect of R_t . The rectifier diodes each have a turn-on voltage of $1.0\ \text{V}$, and the power supply is designed to provide up to $500\ \text{mA}$ of current to the load. The current i_{com} (like i_{ADJ} in an adjustable regulator) is negligibly small. Resistor R_b is a bleeder resistor that discharges capacitor C_{fil} quickly when AC power is removed; of course, it also draws current while the power supply is on.



2. For the power supply circuit considered in the previous problem, find:
 - a. the approximate ripple voltage across the filter capacitor C_{fil} at the maximum load current ($500\ \text{mA}$).
 - b. the approximate time-average power dissipated by the three-terminal regulator.
 - c. the line regulation expressed in the mV/V unit, assuming that measurements reveal an output voltage ripple of $10\ \text{mV}$ at the maximum load current of $500\ \text{mA}$.

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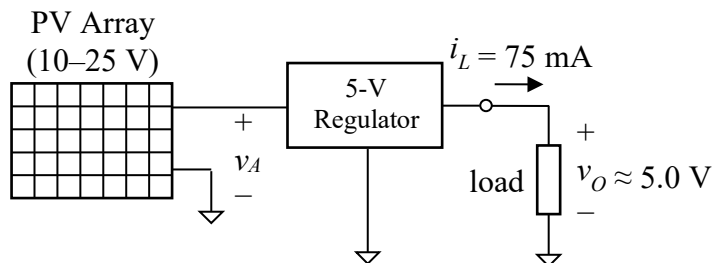
3. A group of engineers performs a series of precision tests on a regulated power supply and obtains the data shown in the table below for the indicated load currents. The variables in the table headings, in order from left to right, are the average load current, the peak load voltage, the input (filter capacitor) voltage ripple, and the load voltage ripple. Ripple voltages are peak-to-peak values. Refer to the circuit diagram in the previous problem for the various voltage, current, and component definitions (although the resistance R_L is not present in this case). Find the load regulation expressed in the mV/mA unit and the line regulation expressed in the mV/V unit for the power supply.

i_L (mA)	$v_{L,pk}$ (V)	v_{Ir} (V)	v_{Lr} (mV)
50	3.2955	0.33	0.25
100	3.2914	0.61	0.46
150	3.2873	0.89	0.67
200	3.2832	1.17	0.88

4. **[boldface text added 10/25/26]** The datasheet for the LM7805 fixed voltage regulator specifies the typical load regulation under the two different conditions listed below. The value given is the change in voltage over the specified change in output current. Find the load regulation for each condition **in the mV/mA unit**. You should obtain two different answers, although they should not differ by much. These types of regulators are typically assumed to be linear devices, so they should have unvarying Thévenin equivalent circuits; that is, one would expect the results for parts **a** and **b** to be the same. The fact that they are different is an indication that the regulator actually has some nonlinearity.

- Load regulation is 9.0 mV for output current variation from 5 mA to 1.5 A
- Load regulation is 4.0 mV for output current variation from 250 mA to 750 mA.

5. The diagram below depicts a photovoltaic array (a set of solar cells) that is being used to supply power to a load. A voltage regulator maintains a nominal load voltage of 5.0 V despite the variable voltage coming from the array. Suppose that the load draws a nearly constant current of 75 mA while the output voltage v_A of the array varies from 10 to 25 V as the sunlight varies throughout the day. Find the resulting small change Δv_O in the load voltage v_O over the course of the day. An abbreviated list of specifications from the regulator's datasheet is given below.



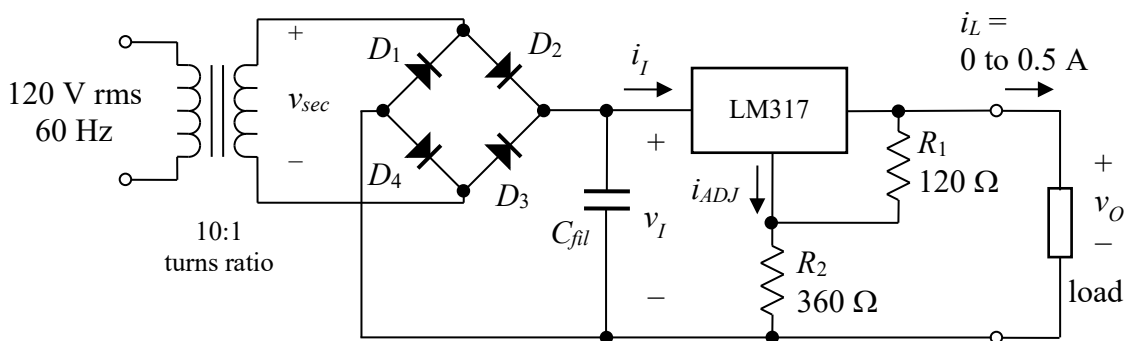
Regulator Specifications
 Nominal output voltage: 5.0 V
 Load regulation: 0.05 mV/mA
 Line regulation: 1.0 mV/V
 Max. output current: 1.5 A
 Min. output current: 5.0 mA
 Drop-out voltage: 2.0 V

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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. As shown below, an LM317 voltage regulator is 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 12 Vrms. The values of resistors R_1 and R_2 have been set to produce a nominal output (load) voltage of $v_O = 5.0$ V. The largest expected load current is 500 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. By KCL, if the current i_{ADJ} in the common terminal of the regulator is negligible, then the input current i_I to the regulator circuit must be approximately the same as the load current i_L for large values of load current. About 10 mA flows through R_1 and R_2 at all times. Find the required value of capacitor C_{fil} so that the minimum voltage V_{min} across the capacitor is roughly 80% greater than $v_O + V_{DO}$.
 - b. Find the worst-case ripple on the capacitor voltage for the case when the load draws a DC output current at the maximum value of 0.5 A. Assume that C_{fil} has the value found in part a.
 - c. Find the approximate time-average power dissipation of the LM317 at full output current ($i_L = 500$ mA).
 - d. Use the information given in the datasheet to express the load regulation in mV/mA. Assume a typical case at 25 °C for the TO-220 package. Note that the data are given for an output current ranging from 10 mA to $I_{MAX} = 1.5$ A.



2. Convert the line regulation specification 0.05%/V to the mV/V unit for the case when the nominal output voltage of a regulator is 12 V and the maximum load current is 500 mA.

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3. Show that the expression for dv_O/di_L for any TEC like the one shown below right is equal to the negative of the Thévenin equivalent resistance; that is, prove the expression shown below left. Note that dv_O/di_L is equal to the load regulation for a voltage regulator circuit if the minus sign is ignored. Also note that $dv_O/di_L = \Delta v_O/\Delta i_L$ for the case of a purely resistive (real-valued) load and a purely resistive Thévenin equivalent impedance.

$$\frac{dv_O}{di_L} = -R_{TH}$$

