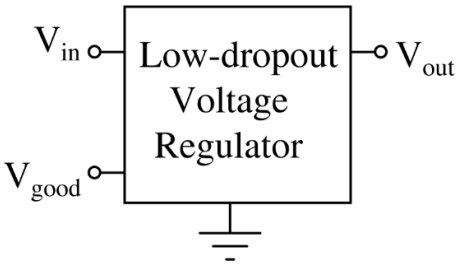
EE313 Laboratory #2

Low-Dropout Voltage Regulator

Design a simple method to measure β of a pnp transistor.

Design a low-dropout (0.7V max) voltage regulator with an output current of 100mA. A green LED should turn on if the regulator output is good. Use a power pnp BJT (BD136) to regulate the voltage, an OPAMP (LM358) to provide the feedback, and a Zener diode as the voltage reference. Select an output voltage of 7V, 8V, 9V, 10V, 11V, or 12V.



Specifications:

1. Line regulation: When V_{in} is between V_{out}+0.7 to V_{out}+6, the output voltage, V_{out}, changes by no more than 10mV when the output current is 20mA (R_L=V_{out}/0.02).
2. Load regulation: When V_{in}=V_{out}+2, the output voltage, V_{out}, changes no more than 50mV when the output current changes between 5mA and 100mA (R_L is varied between V_{out}/0.005 to V_{out}/0.1)
3. An output short circuit current of smaller than 250mA when V_{in}=V_{out}+0.7.
4. A green LED should turn on if the regulation is achieved. Otherwise, it should turn off, for example, because the input voltage is too low or the output current is too high.

Preliminary work (Due February 25, 2024)

Simulate your design using transient analysis of LTSpice to show the performance under four conditions given above: (Use the provided Spice files, LM358.txt for LM358 and BD136.txt for BD136 simulation. (Place LM358.txt and BD136.txt in the working directory. Insert .include LM358.txt and .include BD136.txt directives into the schematic. Define the Value property of the opamp2 symbol as LM358 and the value property of the pnp symbol as BD136.)

Use a Zener diode connected to the output via a series resistor to provide the reference voltage. Note that a Zener diode should dissipate no more than 100mW. An OPAMP can compare the reference voltage with a scaled version of the output voltage to provide the base current of the PNP transistor as feedback.

Use a 3.3Ω resistor in series with the emitter of the PNP transistor to provide β stability.

You need to stabilize the feedback loop by using a capacitor between the output pin and the OPAMP's negative input pin to slow the OPAMP's response.

Use an electrolytic capacitor at the output to provide stability.

From the datasheet of BD136, find the junction to ambient thermal resistance ($R_{\theta JA}$), junction to case thermal resistance ($R_{\theta JC}$), and the maximum junction temperature (T_{Jmax}). Estimate the junction temperature (T_J) and case temperature (T_C) of BD136 when V_{in} is 3V greater than V_{out} and when a

load resistor is connected at the output, drawing a current of 80mA. Assume that the ambient temperature is T_A=25°C.

Provide a schematic of your design, showing a component list. Use Diptrace to generate the schematic of your design.

Upload your LTSpice source file *.asy into Moodle.

Experimental work (Due March 3, 2024)

Measure β of the BD136 pnp transistor.

Build your design on a breadboard. Test the four conditions given above.

Provide a picture of your breadboard in the report.

Calculate the dissipated power on the load resistor. Note that common axial resistors can dissipate only 250 mW. You must use a power resistor or several resistors in series/parallel if the power dissipation exceeds this value.

Set the conditions that you assumed for BD136 case temperature estimation. Measure the case temperature of BD136 using a thermocouple connected to a multimeter.

Connect the heat sink to BD136. Keep the conditions the same. Measure the heat sink temperature after it reaches a steady state. Find the thermal resistance of the heat sink.

Grading criteria:

Preliminary work (10 pts)

β measurement method. 1pt.

Nice looking schematic with component list: 1pt.

Satisfaction of all four criteria in LTSpice: 6pts, 1.5 pts each

Temperature analysis of BD136: 2pts

Experimental work (10 pts)

β measurement. 1pt.

A neat, easy-to-follow, and easy-to-debug circuit implementation on the protoboard. 1pts

Experimental satisfaction of all four criteria: 6 pts, 1.5pts each

Temperature measurements and results: 2pts