EE 140/240A Prof. Pister
Spring 2017

Homework Assignment #8.1

Due by online submission Wednesday 3/22/2017 (Thursday at 9am)

1. A particular diode D1 has a saturation current of 1fA, and at 10uA current at room temperature the diode voltage has a temperature coefficient of -1.5mV/K. You are using copies of this diode to make a bandgap reference as in Lab 4 (where D1 is Q2), with D2 composed of n=144 copies of D1. You can use the approximation that ln(144) ~= 5. Assuming that the current in both diodes is maintained at 10uA
    a. What is the voltage on D1 at room temperature?
    b. What is the voltage on D2 at room temperature?
    c. What is the different between the two diode voltages at 200K, 300K, and 400K?
    d. What is the temperature coefficient of the voltage on D2?
    e. Carefully sketch by hand the voltage on D1, the voltage on D2, and the difference between them as a function of temperature from 200K to 400K. Have your vertical axis go from 0 to 1.5V
    f. What would change in this plot if the current were to increase by a factor of 2?
2. Using the diodes from the previous problem in the bandgap circuit from Lab 4, and assuming a desired 10uA current at room temperature,
    a. what is the value of R1 that will give that current?
    b. what will the voltage across R1 be at 200K? 400K? What will the current be?
    c. if you use R2=2*R1, what will the voltage across R2 be at 200K, 300K, and 400K?
    d. carefully the output of the bandgap circuit using R2=2*R1, on the same plot as in the problem above.
    e. What is the temperature coefficient of the bandgap voltage? Why? How would you fix it?
3. For the bandgap reference in Lab 4, if you were to cut the wires to the inputs of the op-amp, and apply a small positive disturbance in the differential voltage at the input of the op-amp, δV_{id}.
    a. Estimate the gain from that differential input to the resulting differential output voltage between nodes A and B. (Recall that the small-signal impedance of a diode is…)
    b. Estimate where the poles and zeros of this feedback circuit are.
    c. Is it possible for this feedback loop to be unstable? If it were unstable, how would you compensate it?
4. [247A] Discuss the stability of the Vt reference from Lab 4 (Razavi Figure 12.3)