EE313 Laboratory #1

Diode Characterization and Differential Temperature Sensor

A. Design a method to measure I_s of a p-n diode.
B. Design a differential temperature sensor using the temperature dependence of a diode forward voltage under constant current with the following specifications (all in the room temperature between 18°C to 28°C.)
    1. When the sensor is at room temperature, the output voltage should be nearly half the supply voltage (Vdd/2 ±0.3V).
    2. The output voltage should show the temperature difference between the room temperature and the temperature of the sensor diode in degrees with a 10% tolerance. For example, a +1-degree difference should give us a change of +1±0.1 V in the output voltage.
    3. A red LED should turn on when the sensor's temperature exceeds +3±0.5°C the room temperature.
    4. The LED should never flicker around the thresholds (it should have a 0.1°C hysteresis).

You are allowed to use only one supply voltage of less than 15 V. Try to minimize the number of components used.

Preliminary work (Due Feb. 11, 2024)

A. Simulate your method to determine I_s of the diode. Compare the finding with the spice model value of I_s.
B. Simulate your design using LTSpice to show that all specifications are satisfied. You may need one adjustable trimmer resistor to achieve accurate temperature-to-voltage mapping.

The default temperature of simulation in LTSpice is 27°C. This can be changed, for example, to 22°C by adding the spice directive

.temp 22

LTSPICE allows setting the device temperature of a component. However, this possibility is not described in the documentation. Control right-click on the diode body and add “temp={t1}” to one of the empty attribute fields after the diode model name (for example, Value2). Then add

.step param t1 begin end stepsize

Spice directive to see the response as a set of curves with different temperatures.

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

Experimental work (Due Feb. 18, 2024)

A. Apply your method to measure I_s of a 1N4148 diode.
B. Build your temperature sensor design on a breadboard. You may use a resistor in physical contact with the sensor diode and insulate it with electrical tape to adjust the sensor temperature. The resistor may be connected to a separate adjustable voltage source to heat the sensor in a controlled manner. Connect your multimeter to the output. Show that it satisfies all the specifications. It is always a good idea to place a decoupling capacitor (100nF) between the

supply voltage and the ground. You may use a thermocouple provided with many multimeters to measure the room and sensor temperatures and calibrate the resistive heater.

Grading criteria:

Preliminary work (10 pts)

I_s measurement method with LTSpice simulation: 3pts

Nice looking temperature sensor schematic with component list: 1pt

Minimized component count of the temperature sensor design: 2pts

Satisfaction of all four criteria in LTSpice: 4pts, 1 pt each

Experimental work (10 pts)

I_s measurement: 3pts

A neat, easy-to-follow, and easy-to-debug circuit implementation on the breadboard. 1pt

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

Preliminary work (10 pts)

Minimized number of components: 3pt

Nice looking schematic with component list: 1pt

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

Experimental work (10 pts)

A neat, easy-to-follow, and easy-to-debug circuit implementation on the protoboard. 2pts

Experimental satisfaction of all four criteria: 8 pts, 2pts each