EE-313 Lab Preliminary Report 1

Bilge Kaan Ateş

February 11, 2024

1. **Introduction:**

Aims of this lab are finding saturation current of a p-n diode and designing a temperature sensor using the temperature-forward voltage relation of a diode.

1. **LTspice Implementation:**
   1. **Measurement method:**

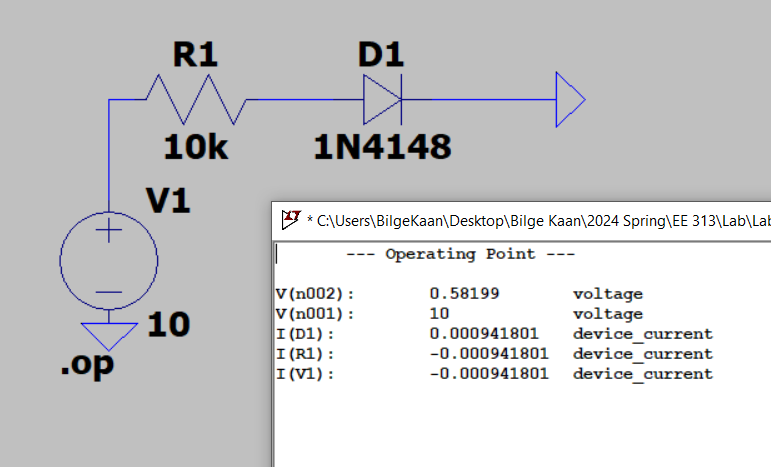


Fig. 1: measurement circuit

For the first part, I designed a basic circuit shown in Fig. 1. I put a series resistor for avoiding the high current and impairment of the diode. can be calculated with the following formula:

(1)

* Total current flows in diode: mA
* Forward voltage of the diode:
* Boltzmann constant:
* Temperature:
* Charge of the electron:
* Ideality factor of the diode:
* We can use:

Therefore, is found as follows:

Which is nearly equal to LTspice value of shown in Fig. 2.



Fig. 2:

* 1. **Differential Temperature Sensor Design:**

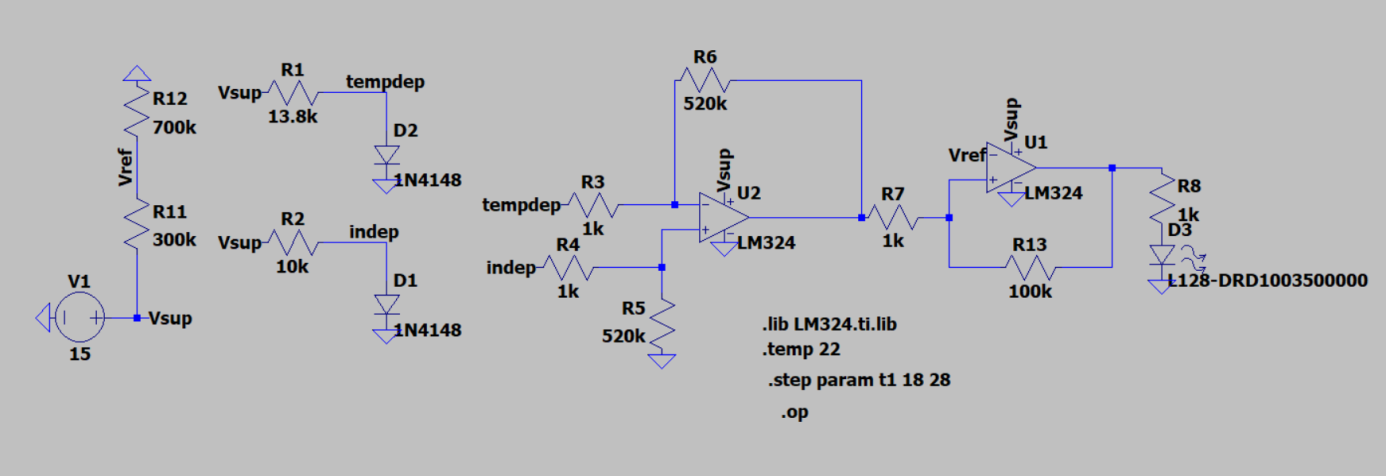
****

Fig. 2: Whole circuit design

I designed a circuit that measures the temperature and maps it on voltage level with a linear relation. Design requirements are as follows:

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 +1degree 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).

Diode-threshold voltage relationship can be observed in formula (1). I obtain after some calculations. In order to designing a temperature sensor with diodes, I used 2 diodes with shunt technique. One of them used for reference point (room temperature) while the other one is used for temperature measurement. After that, I used differential OPAMP for comparing the diodes threshold voltages generate an output voltage as expected. Differential OPAMP’s output voltage formula is as follows:

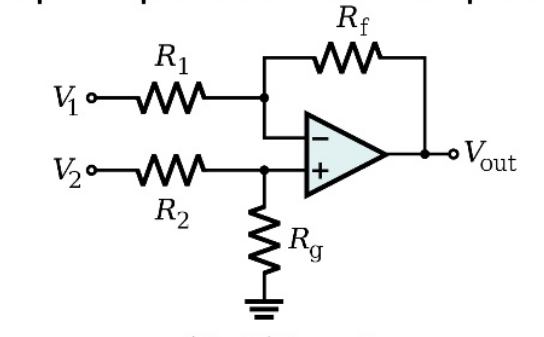


Fig. 3: Differential OPAMP schematic

(2)

If then we have

As a result, I used and obtain the amplification coefficient as 520 since is not exactly -2mV/K. Consequently, I satisfied the second requirement. To achieve output voltage equals to the half of the supply voltage, I used formula (1) and increase the value of series resistor of temperature. Hence, I obtained a bias voltage that shifts the output voltage forward at the room temperature. So, first requirement satisfied as well.

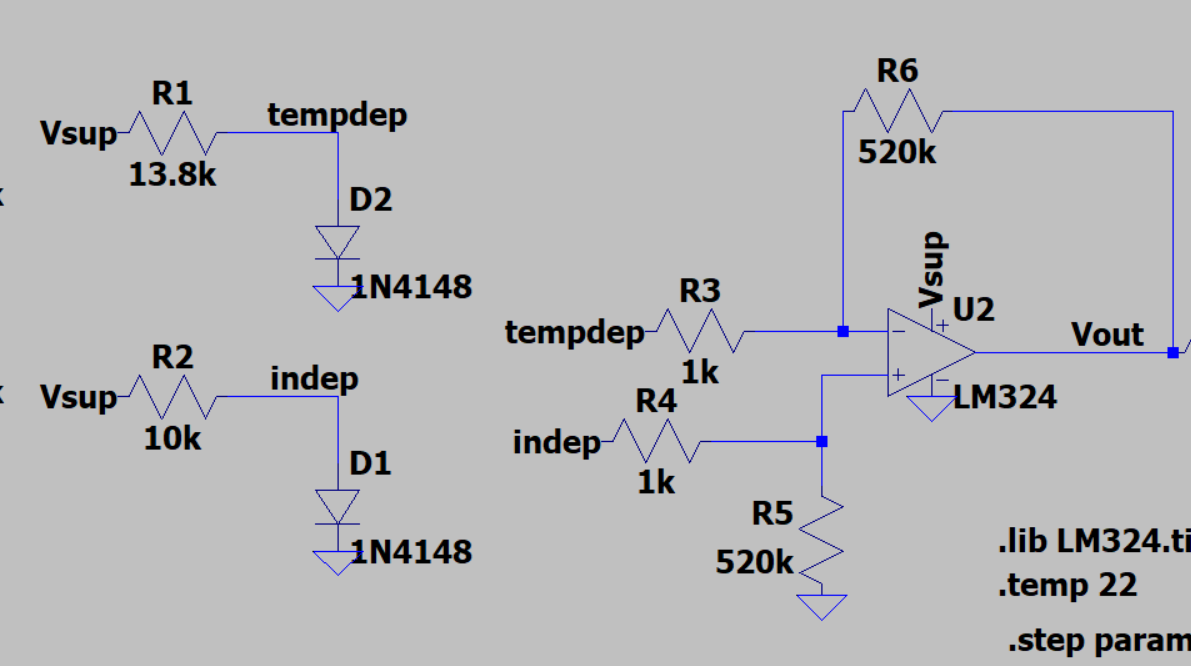


Fig. 4: Corresponding part of the circuit

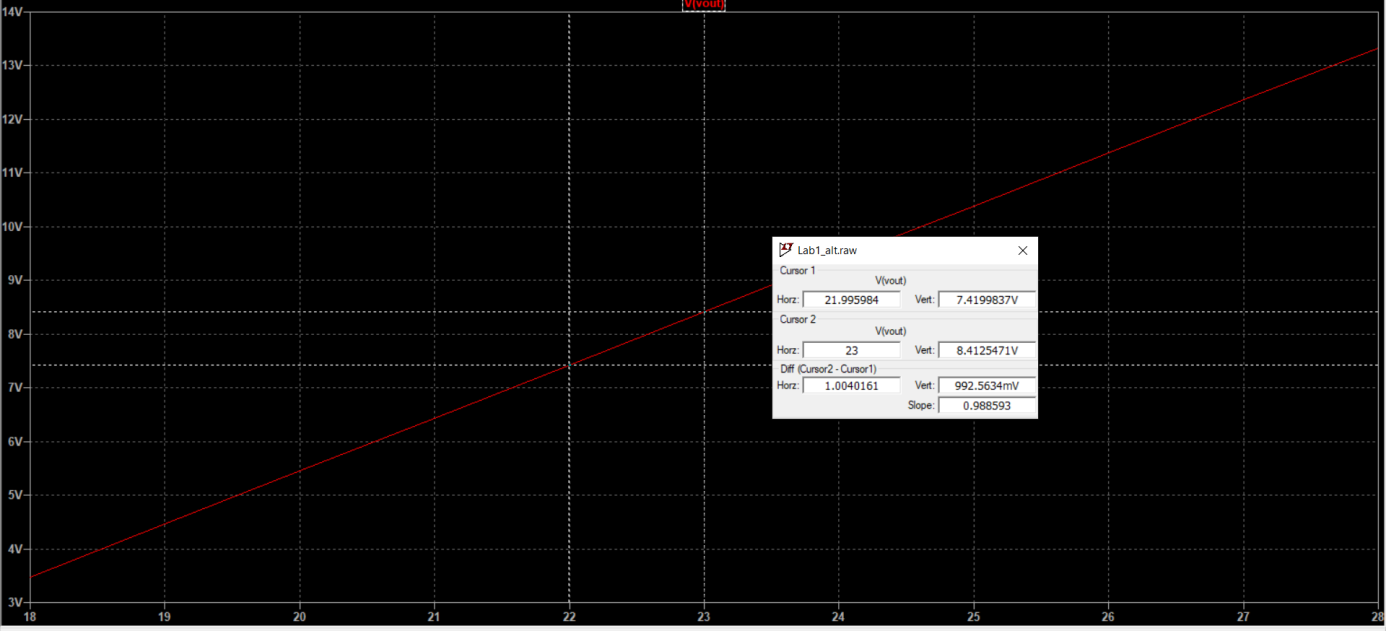


Fig. 5: Accurate voltage-temperature relation.

After I obtained the , I used a comparator OPAMP with to satisfy the third requirement that when temperature sensor exceeds 3C°, light the led. I achieved this at 25.1C° (3.1C° higher than the room temperature). Thus, comparator OPAMP goes high when the exceeds 10.5 V, 3C° higher than the room temperature. I put 1kΩ series resistor to led limit the current. Finally, I used hysteresis method (positive feedback) to avoid from flicker around the threshold voltages. For the positive feedback resistors formula given as follows:

(3)

Hence, I used 1kΩ/130kΩ ratio for this purpose. Second part of the circuit and its responses can be seen in Fig. 6 and Fig. 7 in detail.

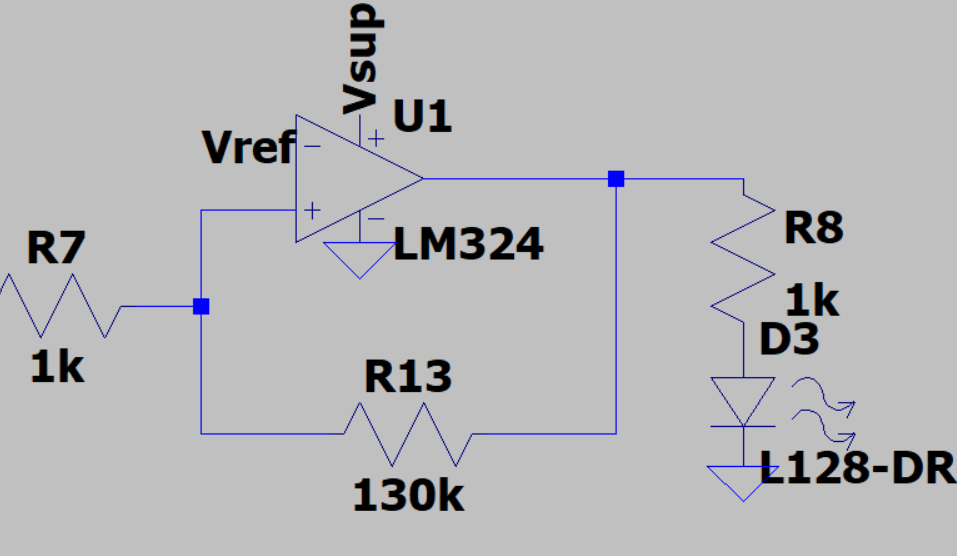


Fig. 6: Comparator OPAMP with hysteresis

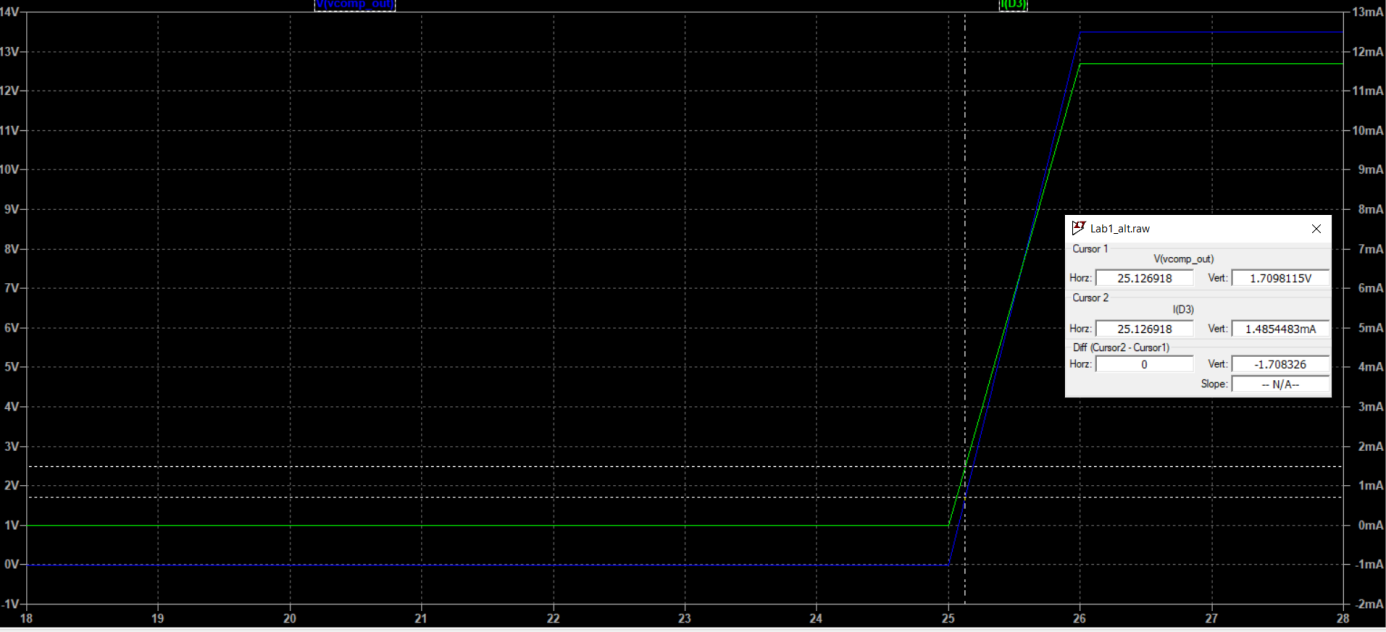


Fig. 7: OPAMP output voltage and current flows through LED

* 1. **Diptrace Schematic:**

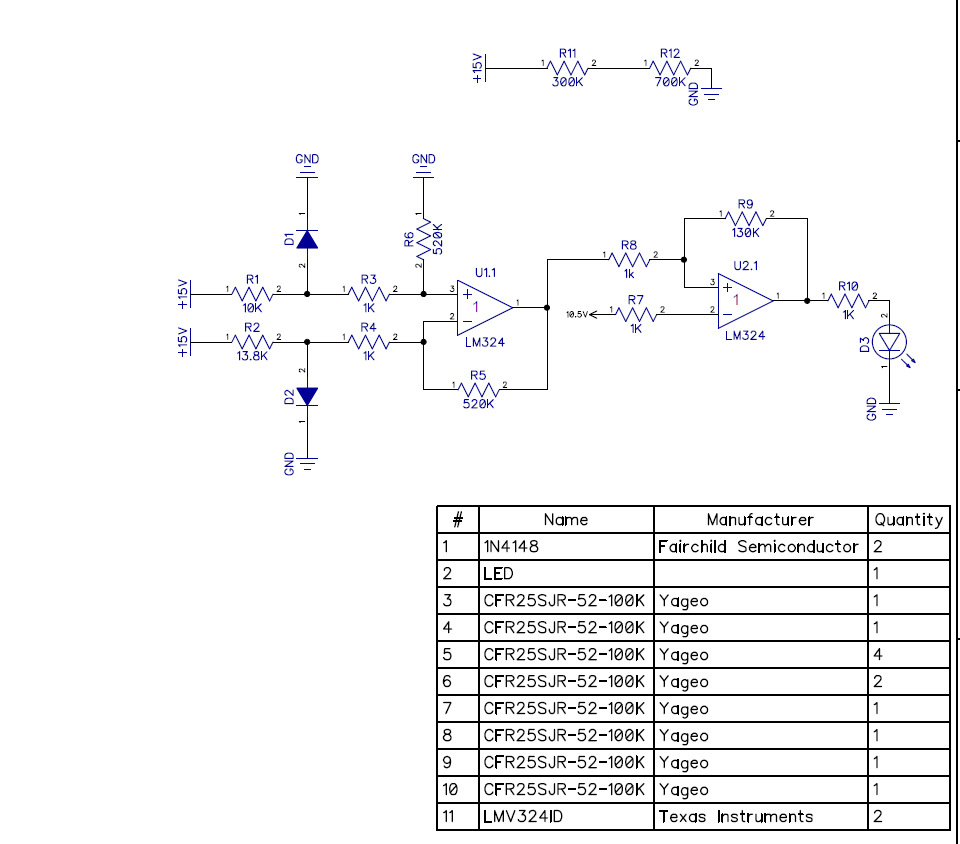
****

Fig. 8: Diptrace Schematic