



**Faculty of Engineering & Technology
Electrical & Computer Engineering Department**

Analog Electronics- ENEE2360

Project#1

Temperature Detector

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Section:

2

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Abstract/Objectives

The aim of this project is to understand how a circuit with a temperature detection change using a sensor thermistor 20k @25C. This simulations will be done using PSPICE program. The circuit contains LM324 op Ams with multiple resistors and 2 LEDs which will react to temperature.

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PSPICE Simulation

Part 1: Simulation with different R_s values

- a) Replace the Red and Green LEDs with D1N4002
- b) Simulate the circuit of Fg.(1) for $R_s = 22K, 25K$, and $20K$

Figure 1.Question a&b

The design of the Circuit using Pspice, R_{10} is R_s :

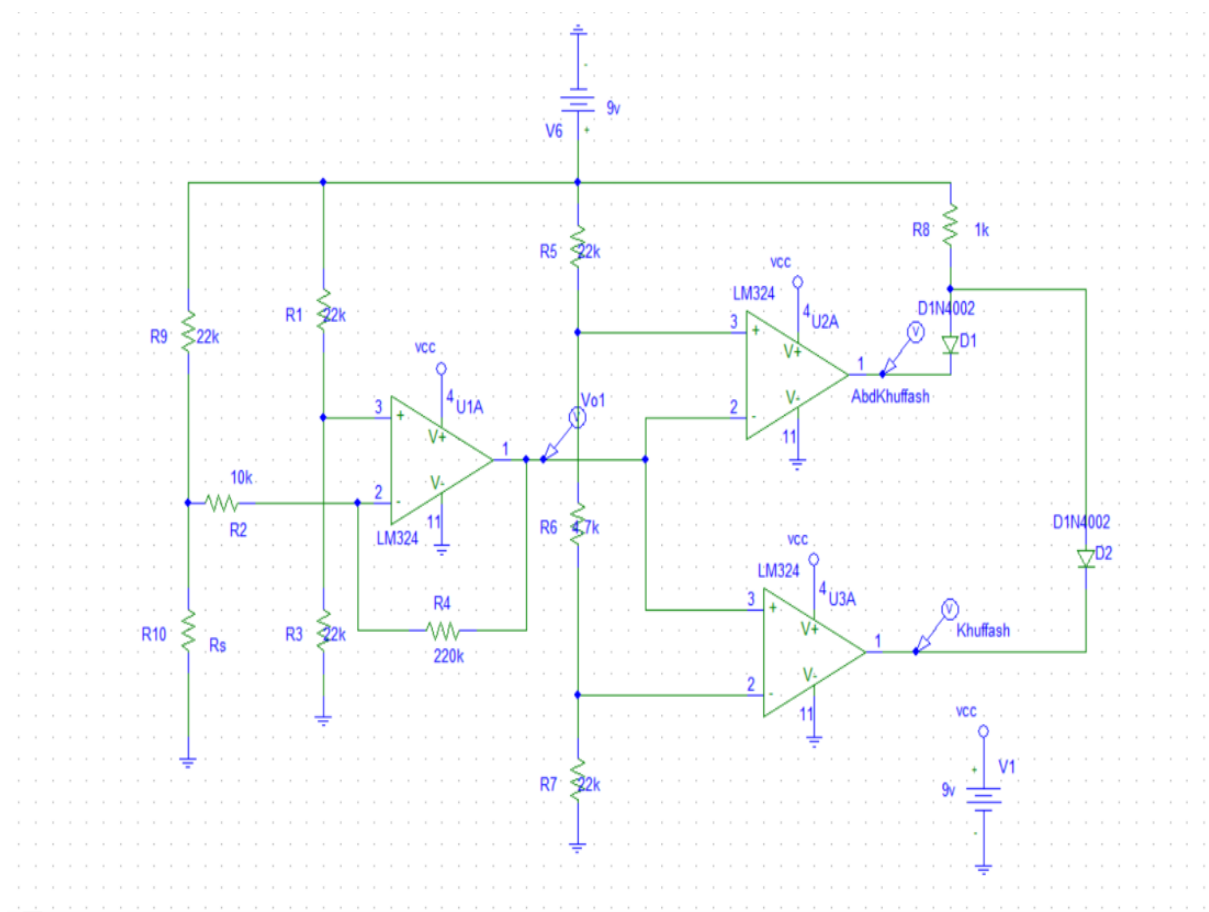


Figure 2.Circuit Design

Assigning values to Rs:

First RS=22k Ohm

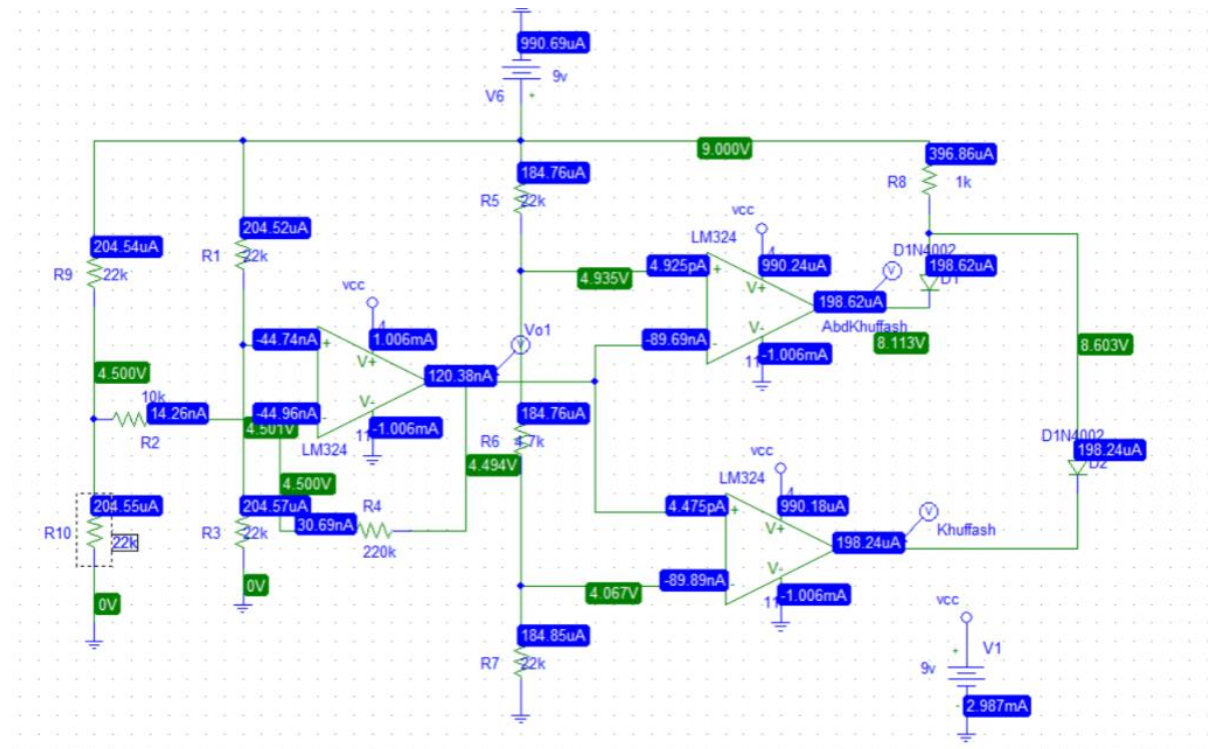


Figure 3.Simulatio RS=22k

Rs= 25k Ohm

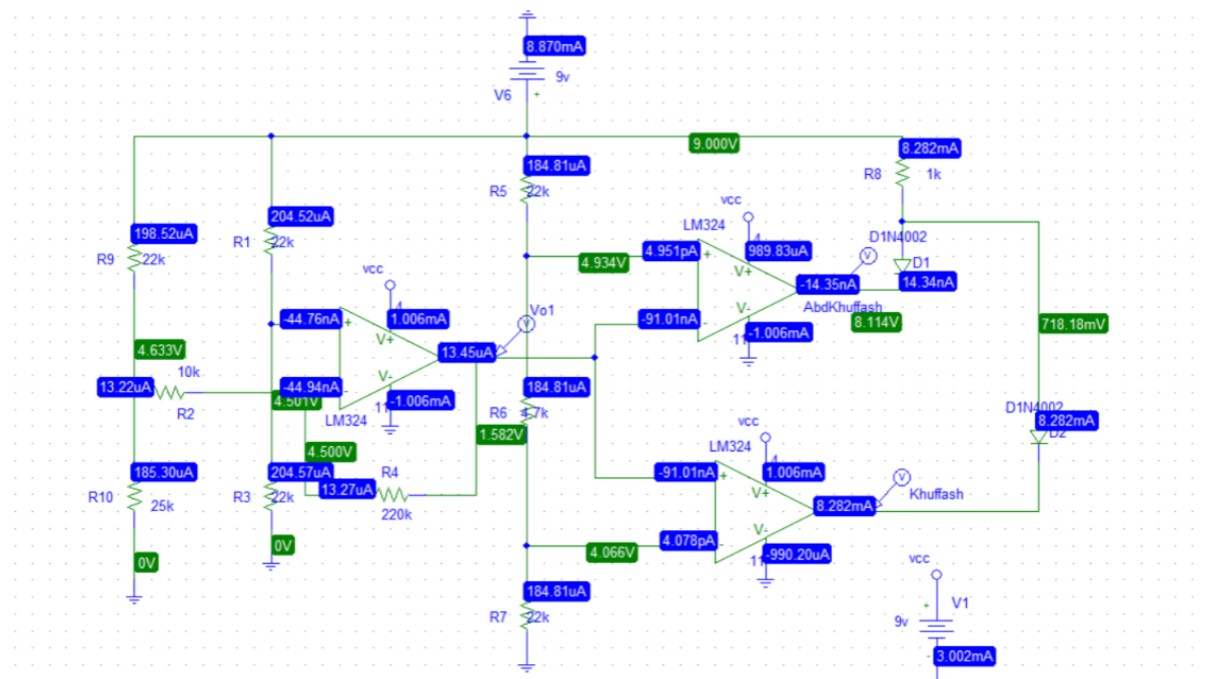


Figure 4.Simulation RS=25k

$R_s = 20k\ \Omega$

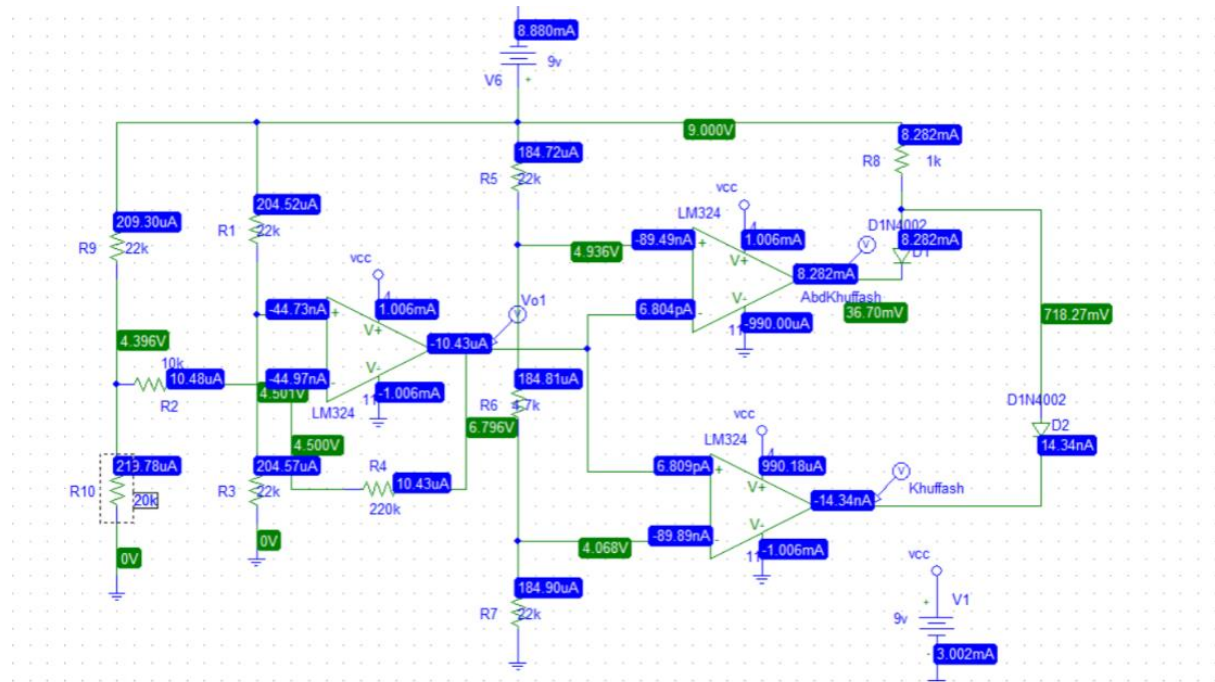


Figure 5. Simulation $R_s = 20k$

Part 2: Replacing The shaded part by a VPWL

c) Replacing the shaded part by a VPWL Voltage source as shown in Fig.(2) , plot $V_{o1}(t)$, $V_{o2}(t)$, and $V_{o3}(t)$.

Figure 6. Question C

After replacing the the shaded part by a VPWL voltage source and configuring its proprarites according to fig.2:

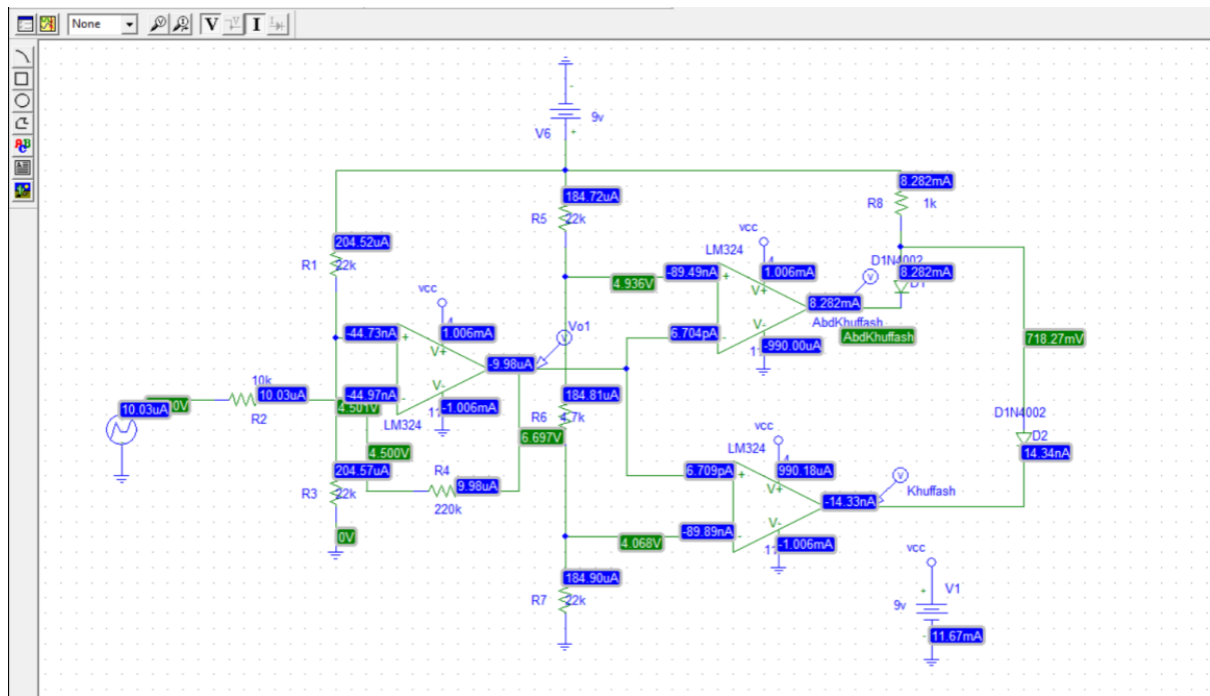


Figure 7.VPWL Circuit

VPWL Settings :

TIME IN MS	VOLTAGE
0	4.4
2	5
4	4.4
6	4.4
8	4.4

Figure 8..VPWL settings

Simulations Settings:

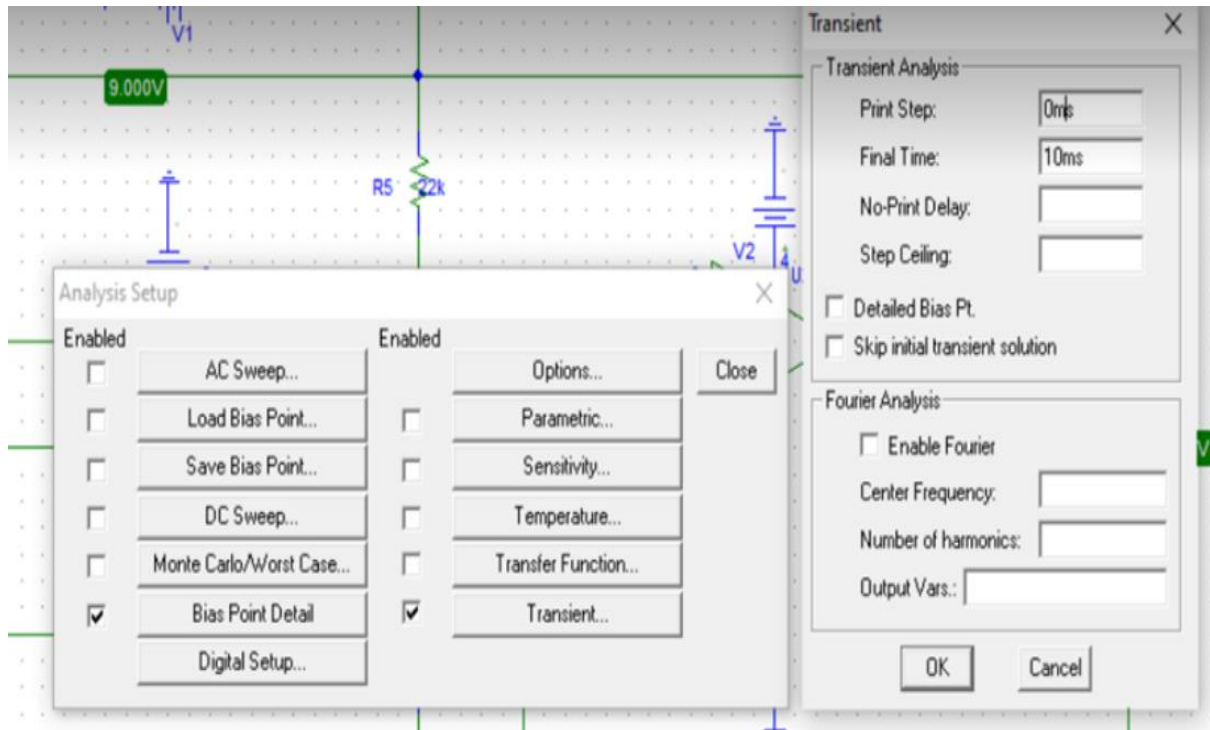


Figure 9. Simulation Settings for VPWM

Results:

The Plot for V01:

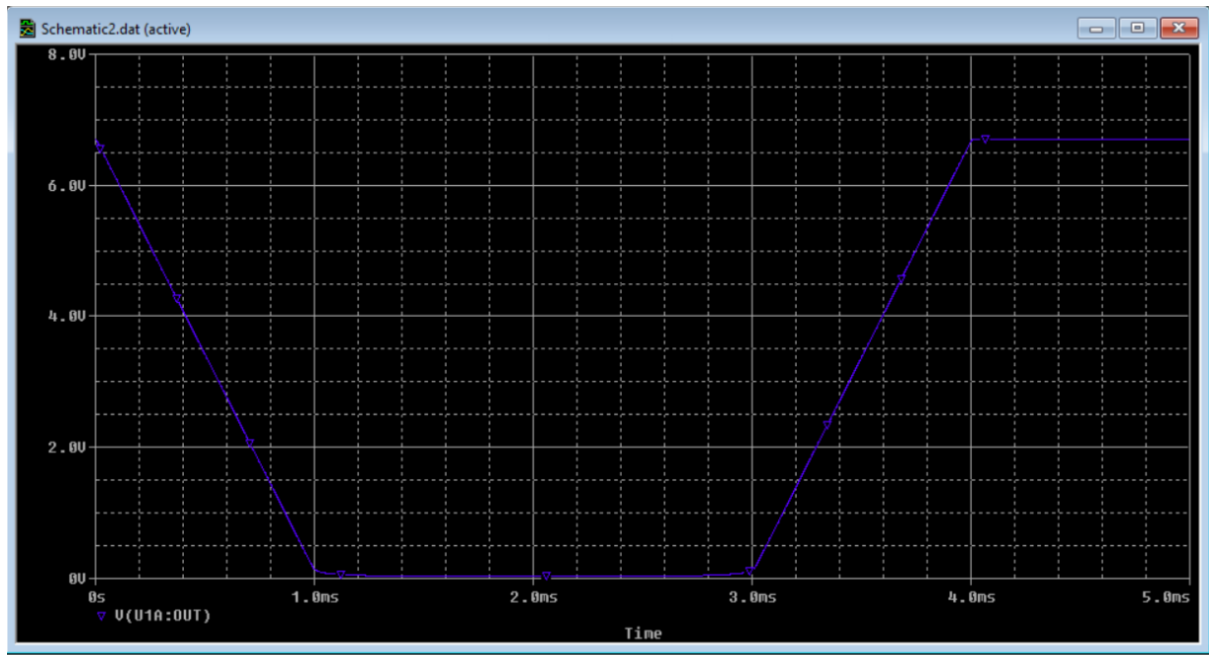


Figure 10.V01 Plot

Plot For V02:

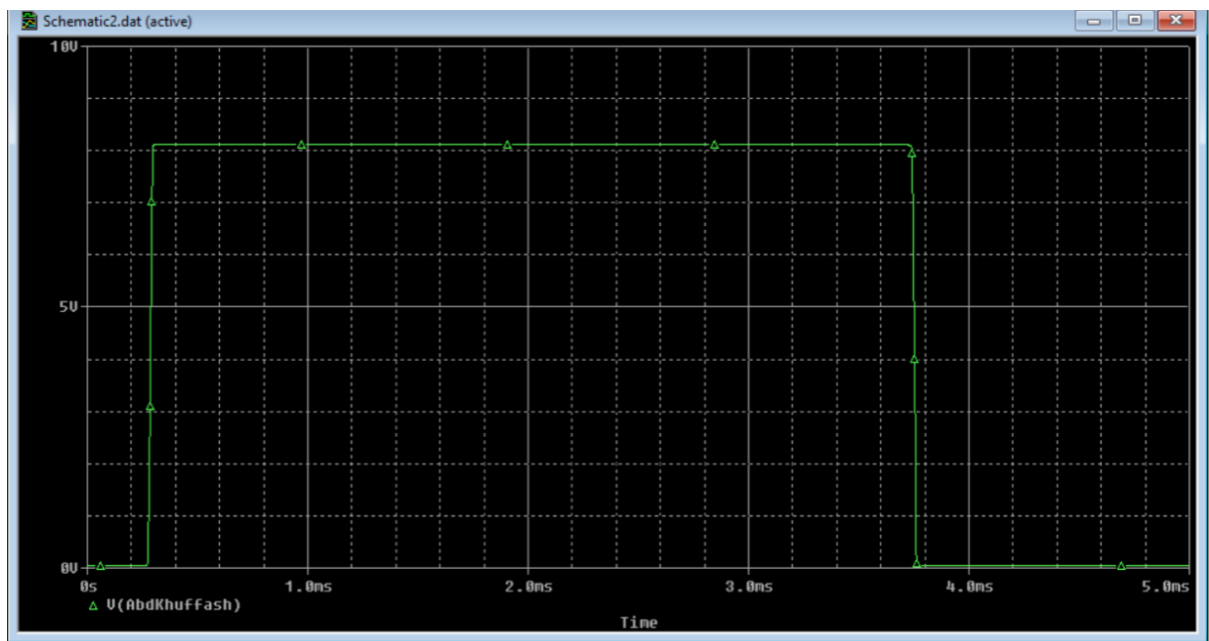


Figure 11.V02 Plot

Plot For V03:

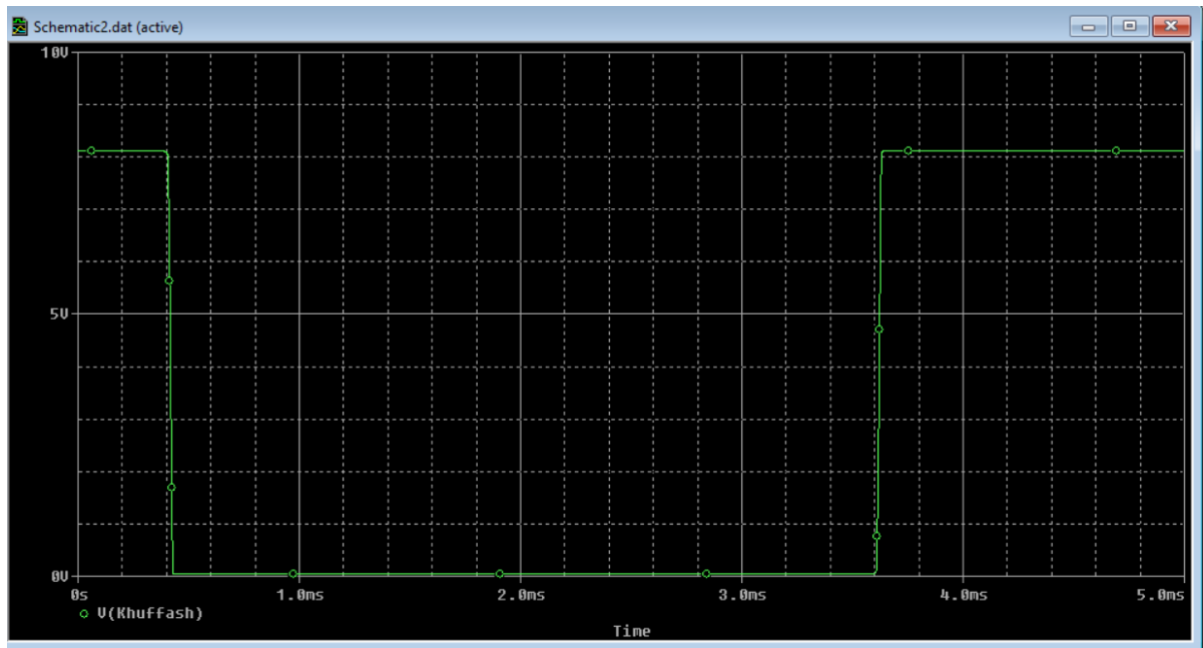


Figure 12.V03 Plot

Part 3: Upper and lower temperatures

d) Estimate the upper limit and the lower limit temperatures from V_{o2} and $V_{o3}(t)$ plots.

Figure 13.Question D

Plot for v_{o2}, v_{o3} , that shows the intersection points between them. They are approximately the upper and lower limit.

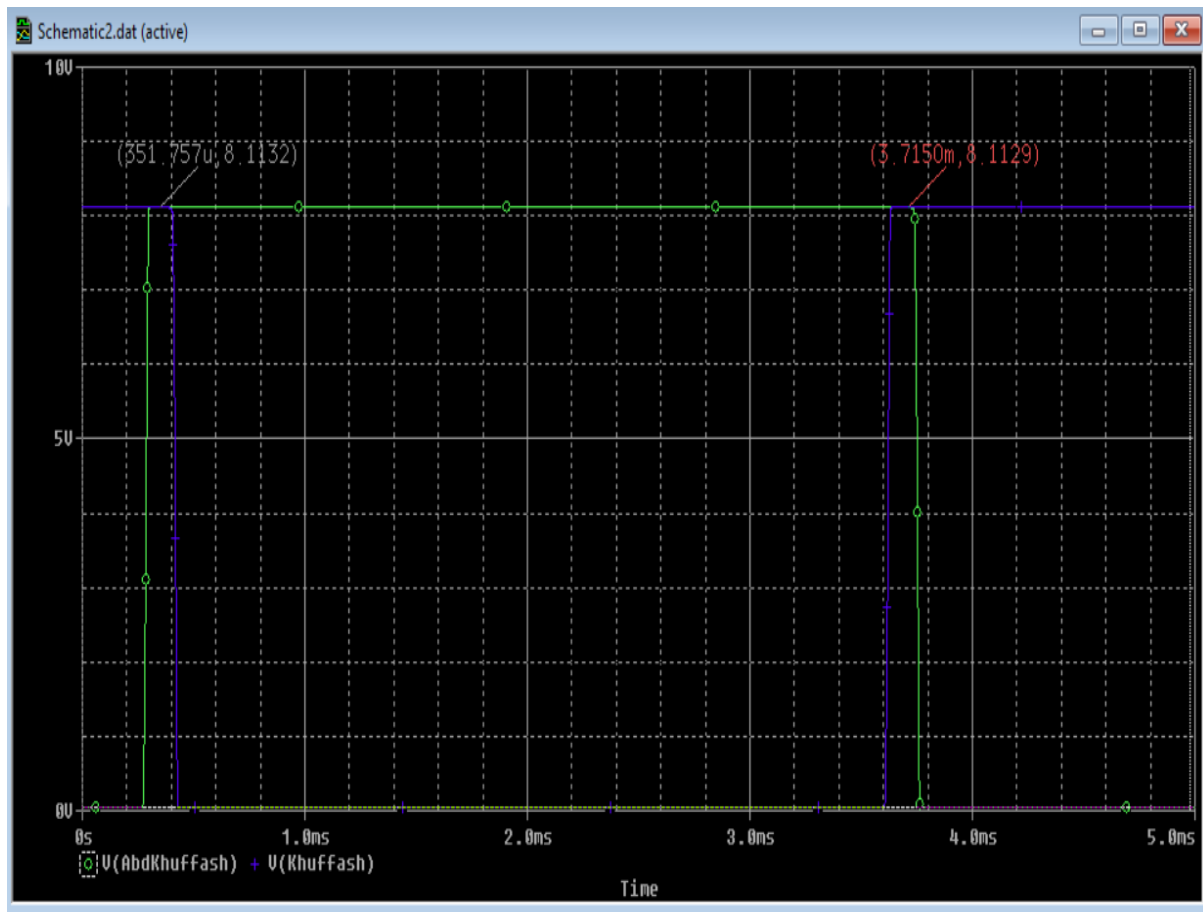


Figure 14.Upper lower Limit

For the calculations in figure 15, we find R_s and then compare with the sheet of temperatures.

From the Simulation in discussion

$$V_{upper} = 5,9 \text{ volt}$$
$$V_{lower} = 3,14$$

For T_{max}

$$R_s = \frac{3,14}{,2m} = 15700$$
$$T_{max} = 30,56$$

For T_{min}

$$R_s = \frac{5,9}{,2m} = 29500$$
$$T_{min} = 17,22$$

Figure 15. Max and Min Temperatures

Part 4: Hand Calculations

f) Calculate by hand the upper threshold and the lower threshold temperature.

Figure 16. Question F

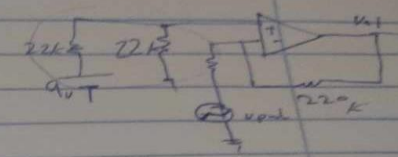
Finding V_{o1} :

Calculation By hand:

to find V_o for op-Amps

Starting With V_{o1} :

Finding thevenin equivalent circuit for the circled part:



$$R_{th} = 22k \parallel 22k = 11k \text{ ohm}$$

$$V_{th} = \frac{22k \cdot 9}{22k + 22k} = 4,5 \text{ volt}$$

Using Super position: Kill V_{th}

$$V_{o1} = -\frac{220k}{10k} \cdot V_{pwl} = -22k (V_{pwl})$$

Kill V_{pwl}

$$V_{(+)} = V_{(-)} = 4,5 \text{ volt}$$

$$V_{o12} = \left(1 + \frac{220k}{10k}\right) \cdot 4,5 = 103,5 \text{ volt}$$

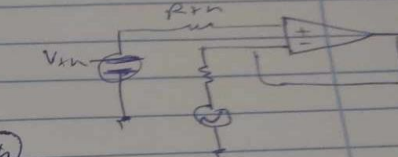
$$V_{o1} = 103,5 - 22 V_{pwl}$$


Figure 17. Hand Cacl. V_{O1}

To find V_{o2} & V_{o3}

To find V_{o2} & V_{o3}

$$V_2(+) = \left(\frac{11.7/22}{11.7/22 + 22} \right) \cdot 9$$

$$\Rightarrow V_2(+) = 1.35 \text{ volt}$$

$$V_3(-) = \left(\frac{22}{22 + 11.7/22} \right) \cdot 9$$

$$\Rightarrow V_3(-) = 7.65 \text{ volt}$$

$$V_2(-) = 10.7$$

$$V_3(+) = 4.7$$

for V_{o2}

$$\text{if } V_2(-) > V_2(+) \Rightarrow V_2 = -V_{sat} = -9 + 2 = -7$$

$$V_2(-) = V_{o1}$$

$$\rightarrow 10.7 - 22 \text{ v pwl} > 1.35$$

$$\rightarrow 4.65 > \text{v pwl} \quad \text{hence} \rightarrow V_{o2} = -V_{sat} = -7$$

$$\text{if } V_2(+) > V_2(-) \Rightarrow V_2 = +V_{sat} = +7 \text{ volt}$$

$$\Rightarrow 4.65 < \text{v pwl} \Rightarrow V_{o2} = +V_{sat} = +7 \text{ volt}$$

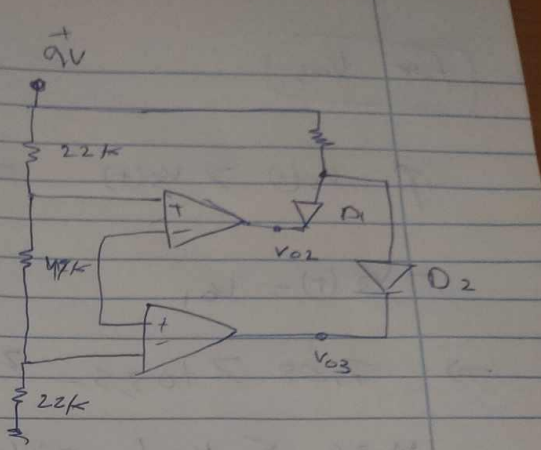


Figure 18. Hand Calcl. V_{o2}

for V_{03}

if $V_3(-) > V_3(+)$ $\Rightarrow V_{03} = -V_{sat} = -7$

$-V_3(+)=V_{01}$

$\Rightarrow 7,65 > 103,5 - 22 V_{pwl}$

$11,36 < V_{pwl} \Rightarrow V_{03} = -V_{sat} = -7 \text{ volt}$

if $V_3(+)>V_3(-) \Rightarrow V_{03} = +V_{sat} = 7 \text{ volt}$

$\Rightarrow 11,36 > V_{pwl} \Rightarrow V_{03} = +V_{sat} = 7 \text{ volt}$

Figure 19.Hand Cacl. VO3

Conclusion

This project focused on exploring a temperature detection circuit using a 20k thermistor and LM324 operational amplifiers. Through PSPICE simulations, we gained insights into the circuit's behavior, accurately monitoring temperature changes with the thermistor and ensuring proper functioning with the amplifiers. The incorporation of LEDs allowed us to visualize the circuit's response to temperature variations, indicating its performance and potential practical applications in electronic systems and environmental control systems. Overall, this project deepened our understanding of temperature detection circuits and provided a foundation for future developments in temperature sensing and control systems.