Name: Anubhav Singh

Roll No.: 210163

Section: A

EC Lab Report

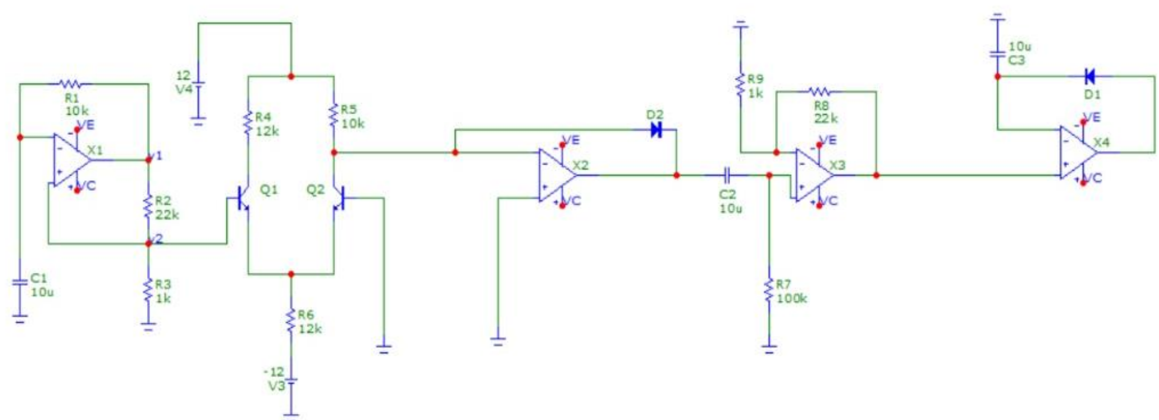
Experiment 2

Part 1:

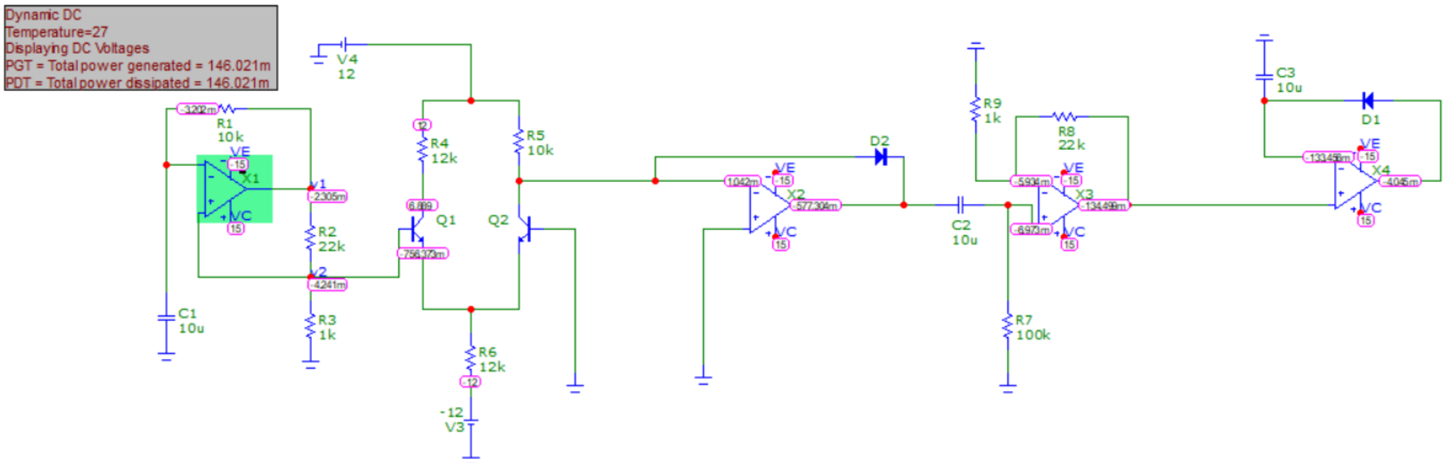
Objective: Design and Implementation of a Temperature Sensor.

- To design a temperature sensor in which output voltage is proportional to the temperature.
- To make all the five stages step by step - Schmitt oscillator, Current Switch, Diode Temperature Sensor, Amplifier + DC offset elimination, and Peak Detector.
- To calibrate and compare the results with that of temperature sensor IC LM35 Precision Centigrade Temperature Sensors.

Design:



Simulation and Simulation Results:



$$V_B = \frac{kT}{q} \ln\left(\frac{I_o}{I_S}\right)$$

$$T(°C) = \frac{V_{B2} - V_{B1}}{\ln(N)} \times \frac{300}{0.02588} - 273$$

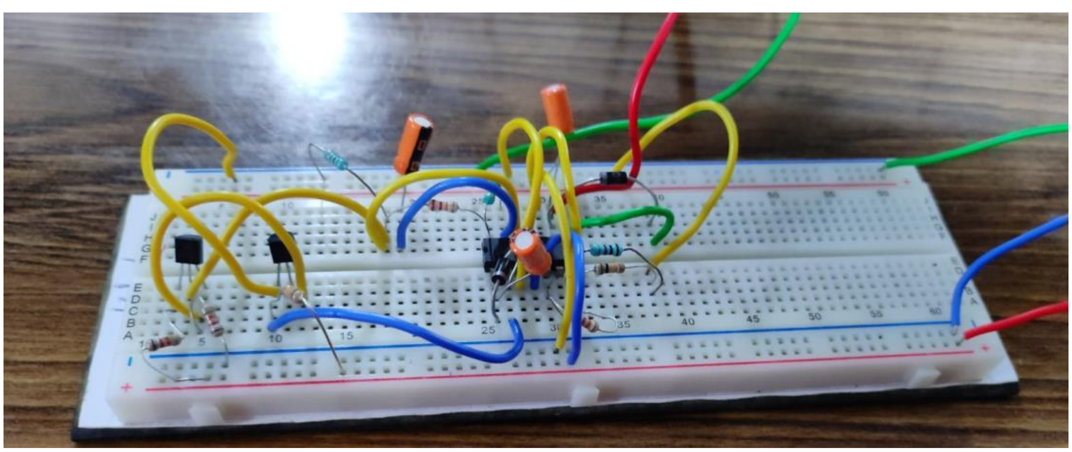
From simulation: $V = 476.76mV$

$$\Delta V_B = 41.45mV \ using \ Gain = 23$$

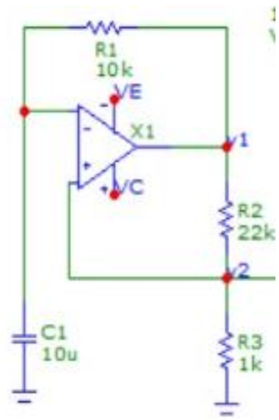
$$Hence, T = 26.54°C$$

In-Lab:

- Circuit on Breadboard:

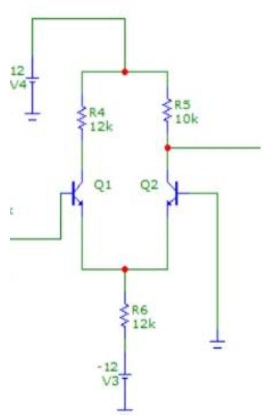


- Stage 1: Schmitt oscillator

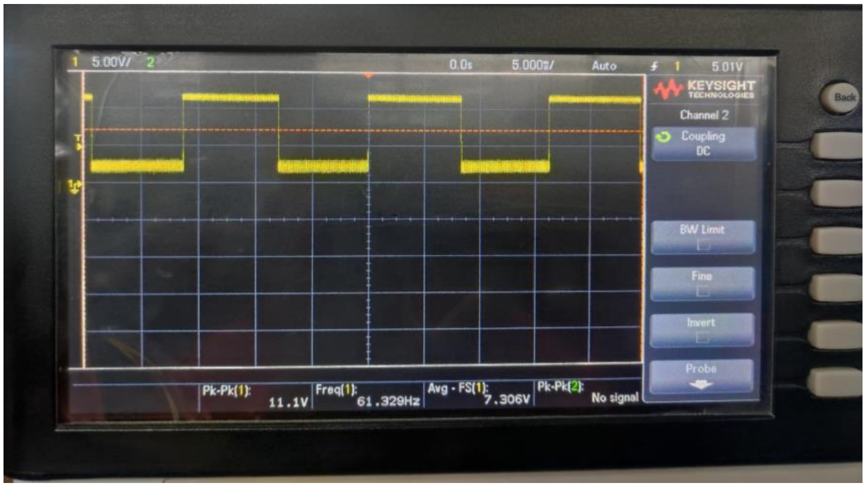


- V_{pp} = 1.09V
- Frequency = 62.456 Hz
- This is used to create a square wave output which will be input of the current switch circuit.

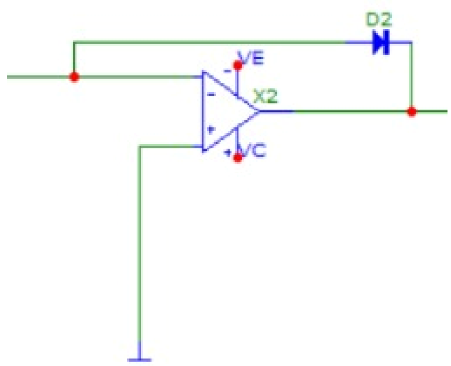
- Stage 2: Current Switch



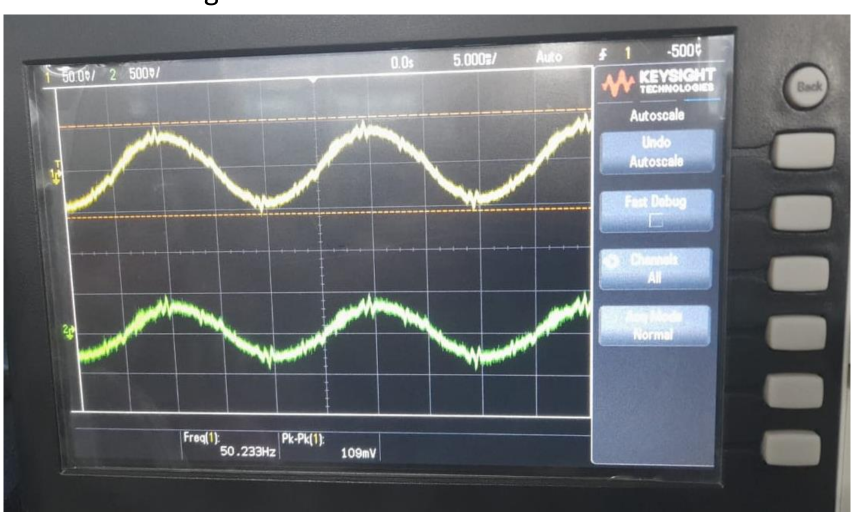
- V_{pp} = 11.1V
- Frequency = 61.329 Hz
- When the input to it is negative, the BJT to which the input is connected is in cut-off and when the input to it is high, the other BJT goes into cut off. Hence, we get a square wave of the current coming out of the current switch.



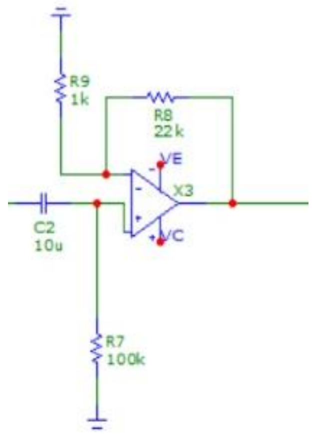
- Stage 3: Diode Temperature Sensor



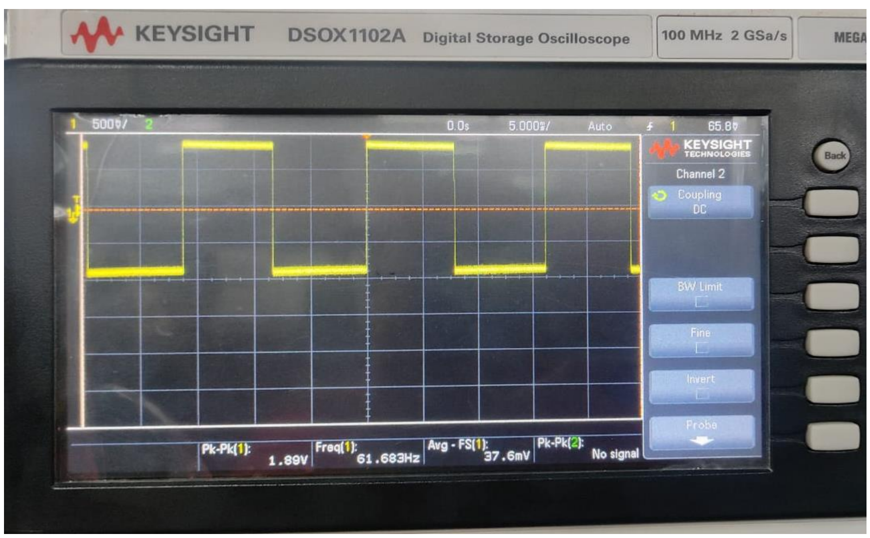
  - V_{pp} = 109mV
  - Frequency = 50.233 Hz
  - The square wave current coming from the current switch is fed into the diode.



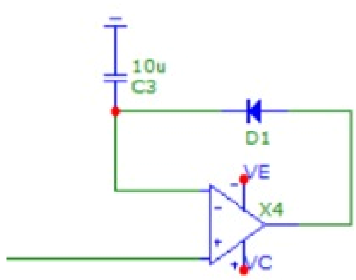
- Stage 4: Amplifier + dc offset elimination.



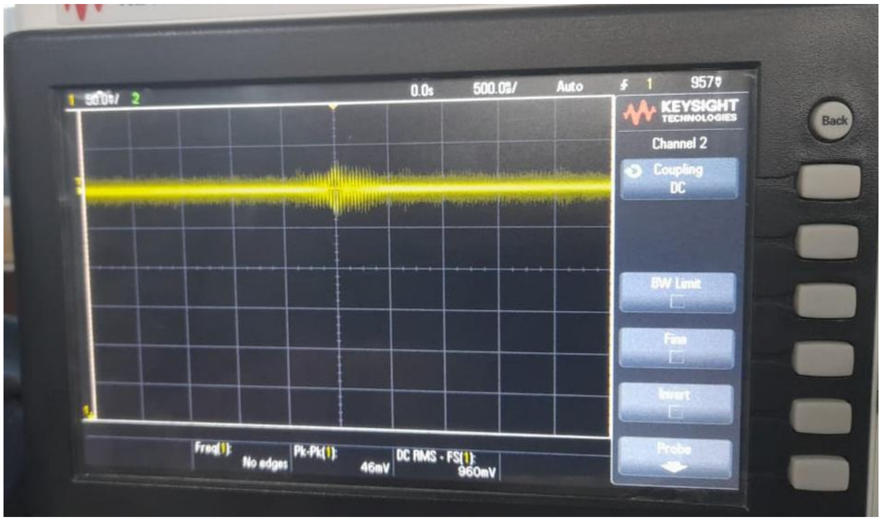
  - V_{pp} = 1.89V
  - Frequency = 61.683 Hz
  - The output of the temperature sensor is passed through the capacitor to block the DC voltage and then passed thought the gain stage for amplification.



- Stage 5: Peak Detector



  - V_{pp} = 960mV
  - Frequency = 61.967 Hz



We calculate the room temperature from the observed values as follows:

Schmidt's Trigger Output = 1.09V

V_{B1} = 4.34121mV, V_{B2} = 811mV, f = 61.967Hz

$$I_1 = \frac{12 - 0.004342}{10000} = 1.2mA,$$
$$I_2 = \frac{12 - 0.811}{12000} = 0.9324mA,$$

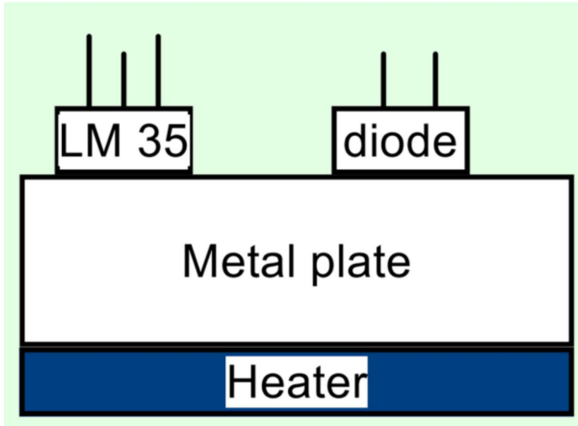
$$N = \frac{I_1}{I_1 - I_2} = 4.49, \quad Gain = 1 + \frac{22}{1} = 23$$
$$\Delta V_B = \frac{434}{1000} \times \frac{2}{G} = 37.74mV$$

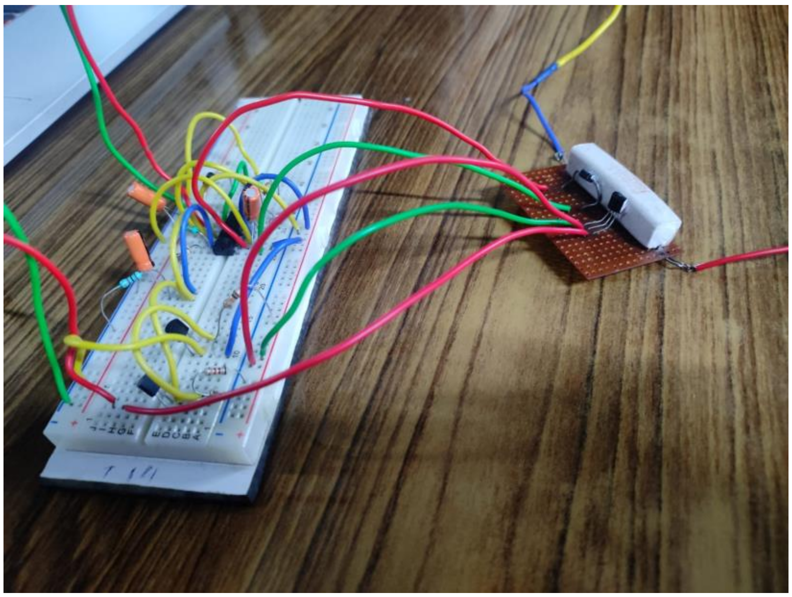
$$T(°C) = \frac{0.037740}{\ln(4.49)} \times \frac{300}{0.02588} - 273 = 18.29°C$$

Conclusions:

- As the temperature of the diode of the temperature sensor is changed, the output of the peak detector across the capacitor increases. This is due to increase in the voltage across diode with increase in the temperature.
- When we completed making the stages, we could see the voltage rising when we put our thumb on the diode, i.e., the temperature rising due to additional body heat.

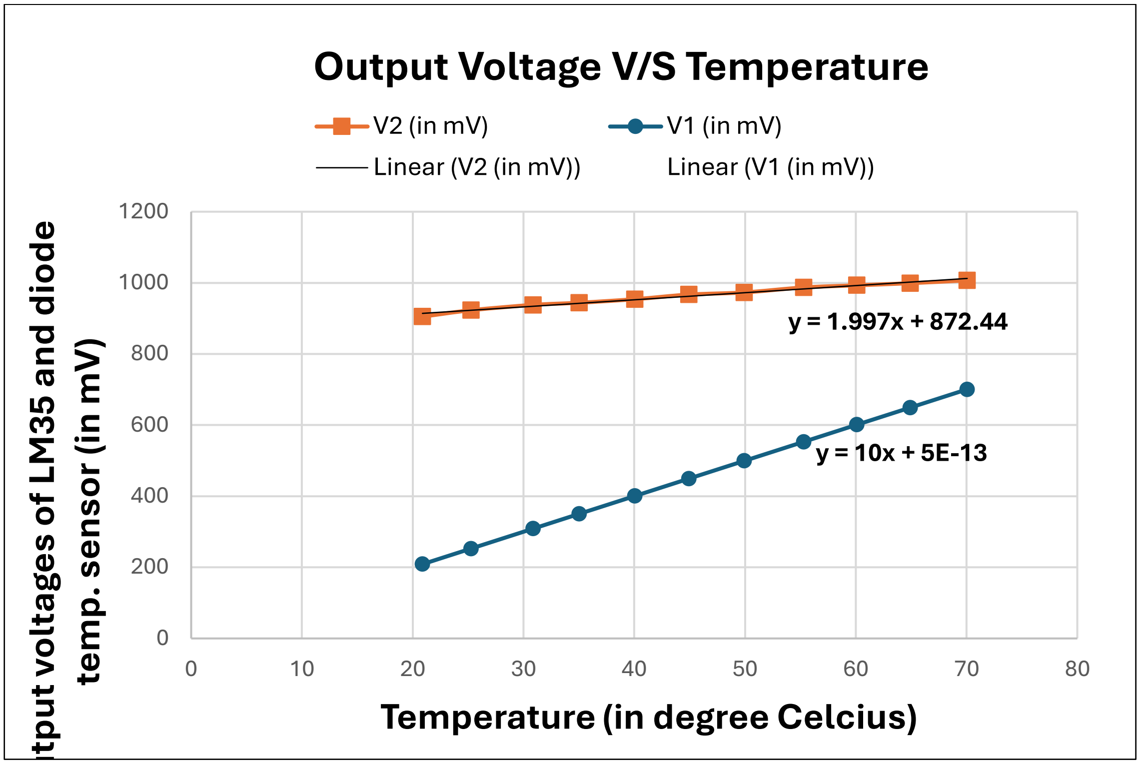
Part 2: Calibration:





V1 corresponds to the output voltage of LM35 IC and V2 corresponds to the output voltage of the temperature sensor we made in the lab.

Temperature ($°C$)	V1(mV)	V2(mV)
20.88	208.8	905
25.27	252.7	923
30.87	308.7	938
35.03	350.3	944
40.05	400.5	954
44.94	449.4	967
49.93	499.3	973
55.29	552.9	987
60.08	600.8	993
64.9	649	999
70.06	700.6	1007



- Some readings in lab:

Conclusions:

- We see a linear rise in output voltage with temperature for LM35 IC and an approximate linear rise in the temperature sensor made in lab. The variation of data points with respect to the best fit line is also very less, indicating good temperature sensor.
- The output of the LM35 IC chip is 10 mV/^{o}C.
- The output of our designed temperature sensor is 1.997 mV/^{o}C.