Progress Report - I

Diode Temperature sensor with Digital display

Group - 8:

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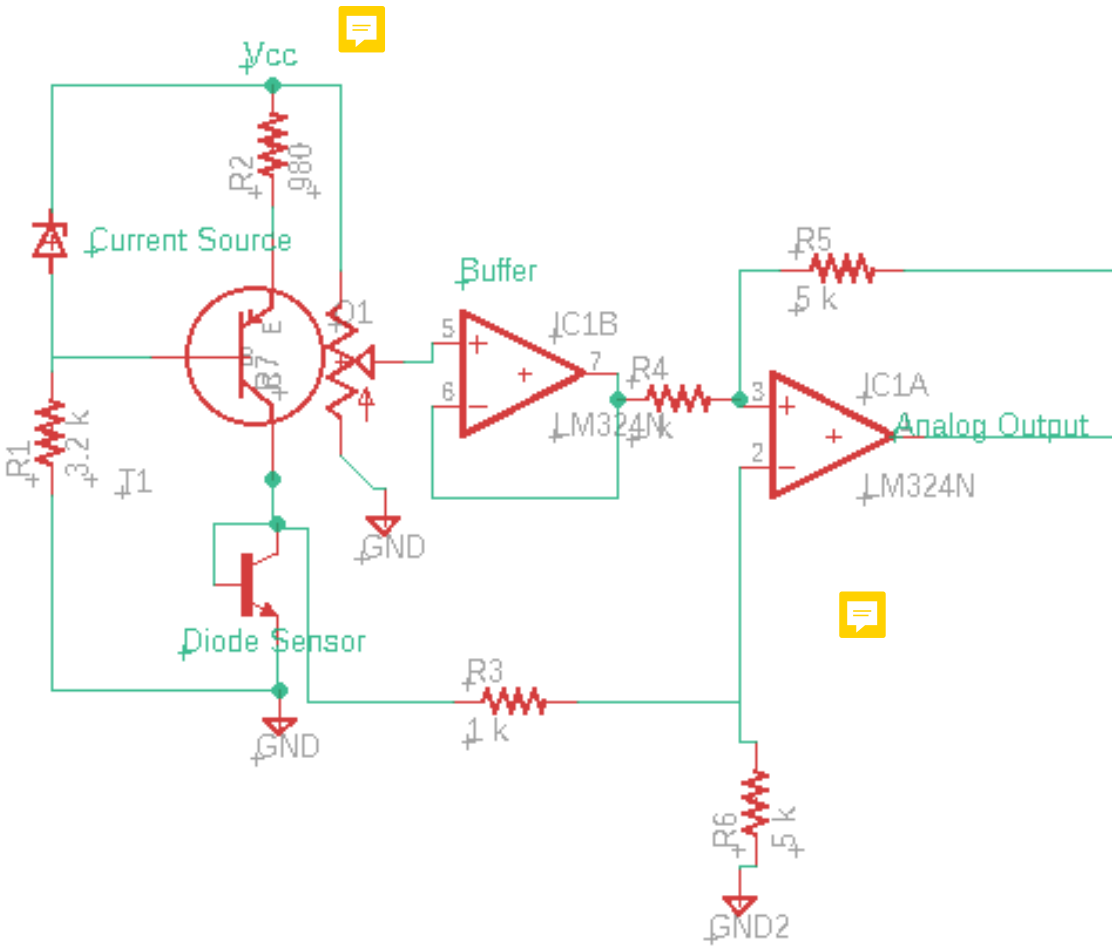
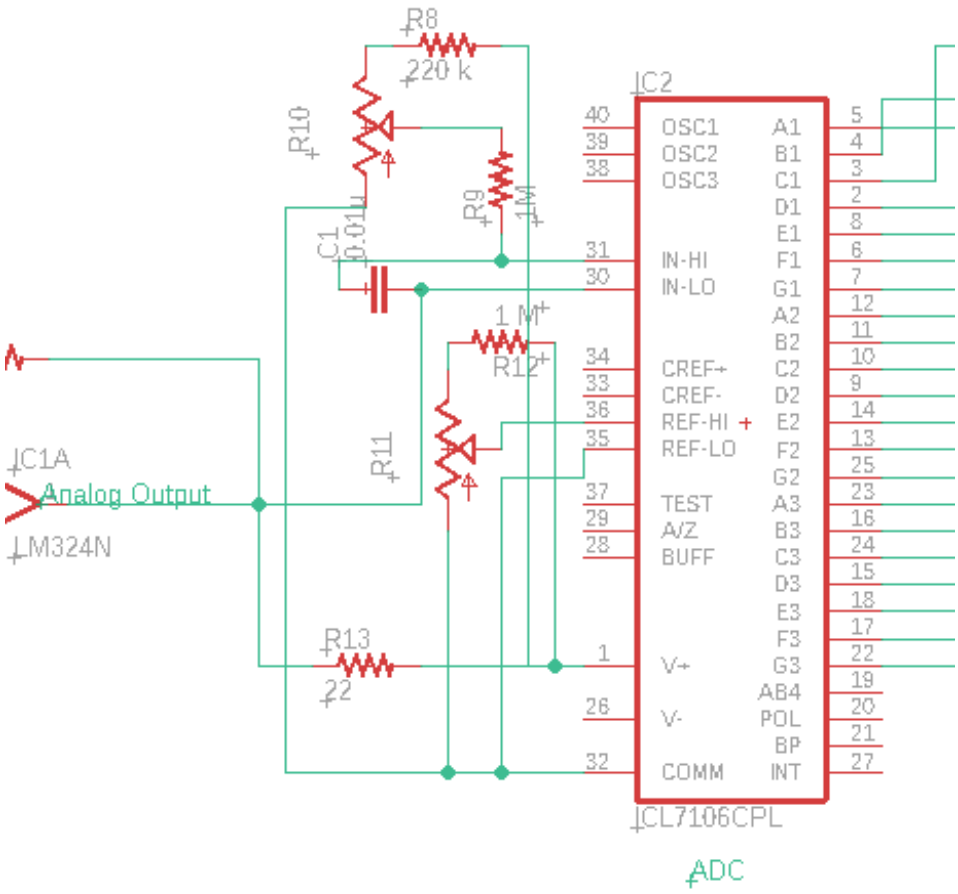
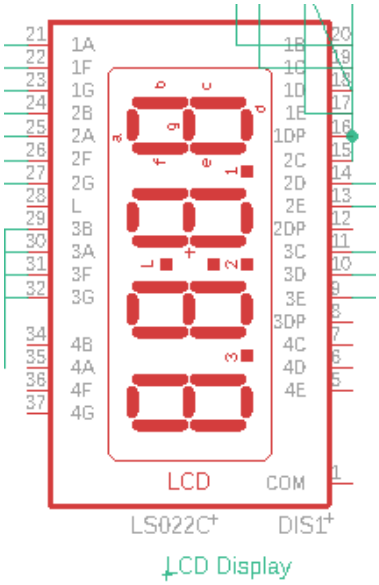
Final Circuit Diagram:



Final Analog part


R8
220 k
R10
R9
1M
C1
0.01u
1 M
R12
R11
IC1A
Analog Output
LM324N
R13
22
IC2
OSC1
OSC2
OSC3
IN-HI
IN-LO
CREF+
CREF-
REF-HI
REF-LO
TEST
A/Z
BUFF
V+
V-
COMM
A1
B1
C1
D1
E1
F1
G1
A2
B2
C2
D2
E2
F2
G2
A3
B3
C3
D3
E3
F3
G3
AB4
POL
BP
INT
ICL7106CPL
ADC

ADC part


1A
1F
1G
2B
2A
2F
2G
L
3B
3A
3F
3G
4B
4A
4F
4G
1B
1C
1D
1E
1DP
2C
2D
2E
2DP
3C
3D
3E
3DP
4C
4D
4E
LCD
COM
LS022C
DIS1
LCD Display

Improvement in design compared to proposal

A) We have changed our ADC and interfacing it with the display section.
Initially we were using a parallel ADC and further converted it to 4 different BCD numbers using combination of a few 8-bit BCD converter and further used bcd to 7-segment decoder for each of the digits.
But after discussing with prof Joseph John, all of this is done by a single IC, which is **ICL7106**. This IC provides output as 21 bits which are basically 3 different 7-segment numbers which could directly be given to the 7-segment display. It takes a differential input voltage as well as differential reference voltage.

Here we need to give a dual voltage i.e. +ve and -ve as the supply to the IC.
The connection for the ADC have been referred from:
https://datasheets.maximintegrated.com/en/ds/ICL7106-ICL7107.pdf

B) Also, the V_{ref} which was found using calibration was pointed out to be dependent on the sensor's output voltage at a given temperature.
To remove this dependence we put a **buffer/voltage follower** taking input the middle pin of potentiometer and output was then given to the non-inverting pin through a resistor.

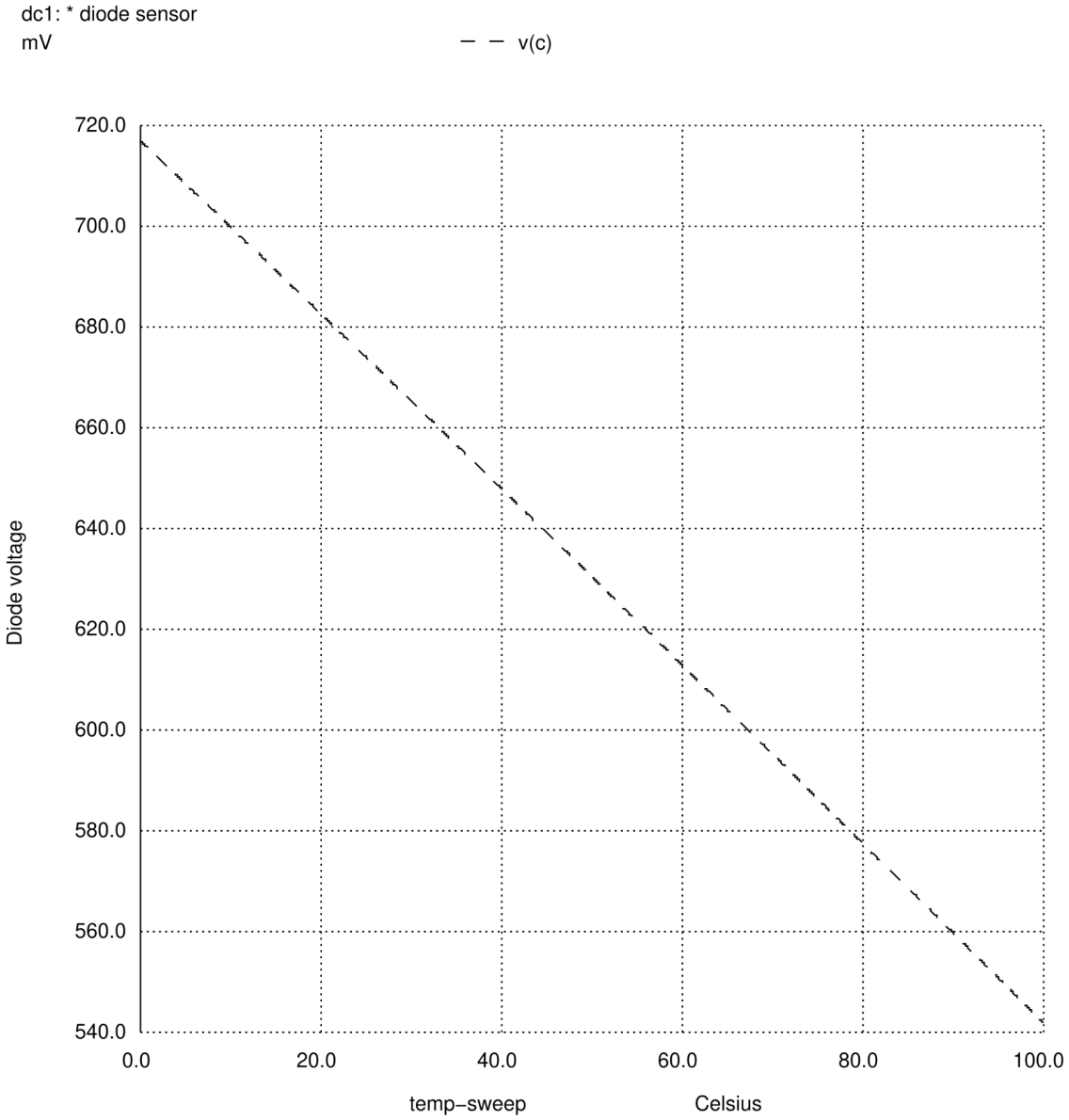
Bill Of Materials:

Component Name	Role in the circuit	Unit price (INR)	Quantity
2N2222 NPN BJT	Temperature sensor diode	15	1
1N4734A	Zener diode in constant current source	20	1
BC547 BJT Transistor	BJT for constant current source	38	1
LM324N	Op-amp in Differential amplifier circuit	300	1
ICL7106	ADC	220	1
LS022C	Displaying the temperature	150	1
Capacitors			
Resistors			
12 V / 7Amp Battery	Supply voltage = 12V	650	1
TOTAL		1393	

Simulation Results of Analog part of the final circuit:

Simulation 1: Simulating the sensor

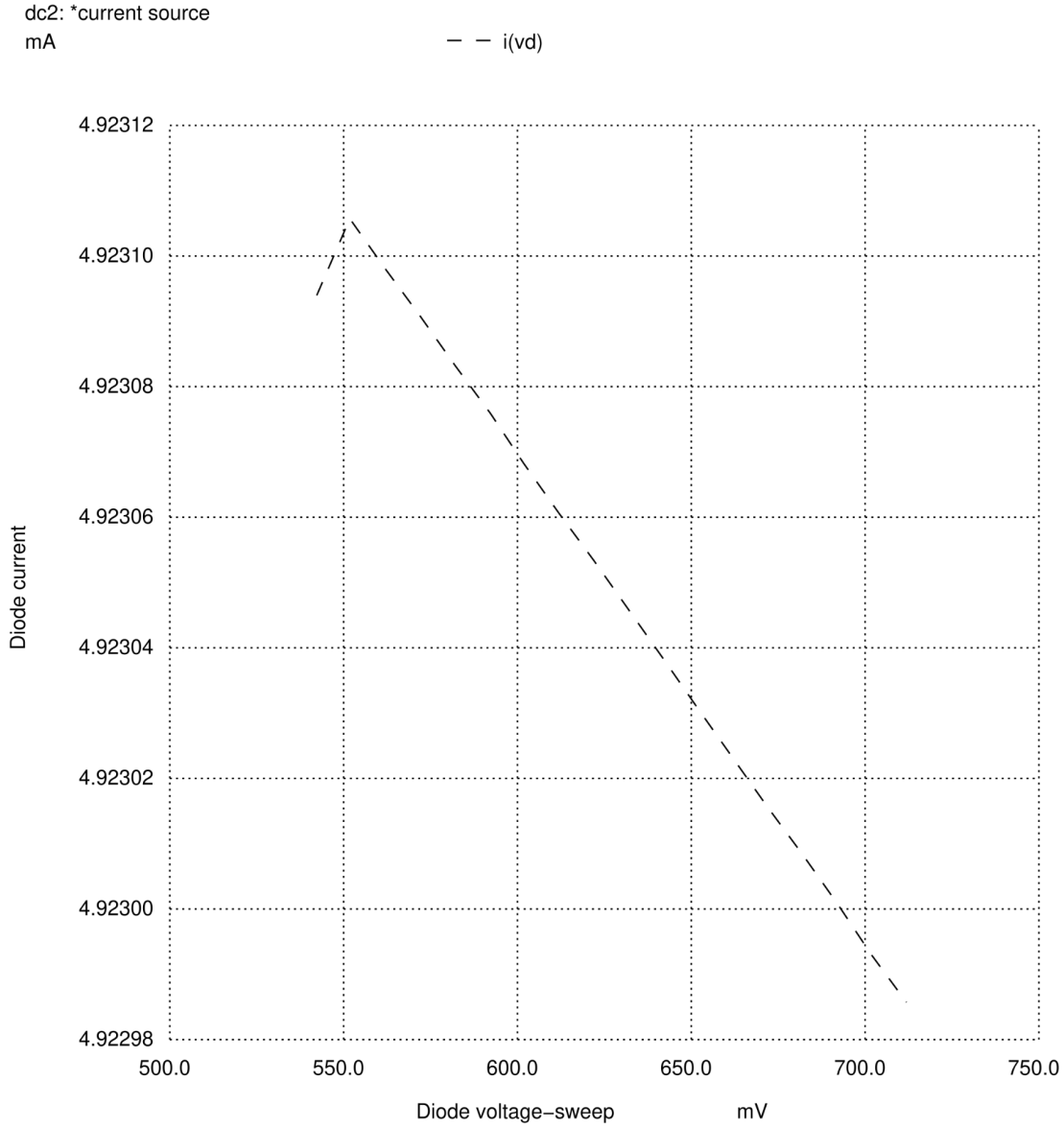
Here, we have used an inbuilt constant current source(of 5mA) provided by ngspice and checked the sensor output corresponding to different temperatures.



The variation of diode voltage with temperature is linear as expected, for 2N2222 spice model the slope of the above plot is -1.75mV/^{o}C. Range of diode voltage is 0.717-0.542V.

Simulation 2: Simulating constant current source

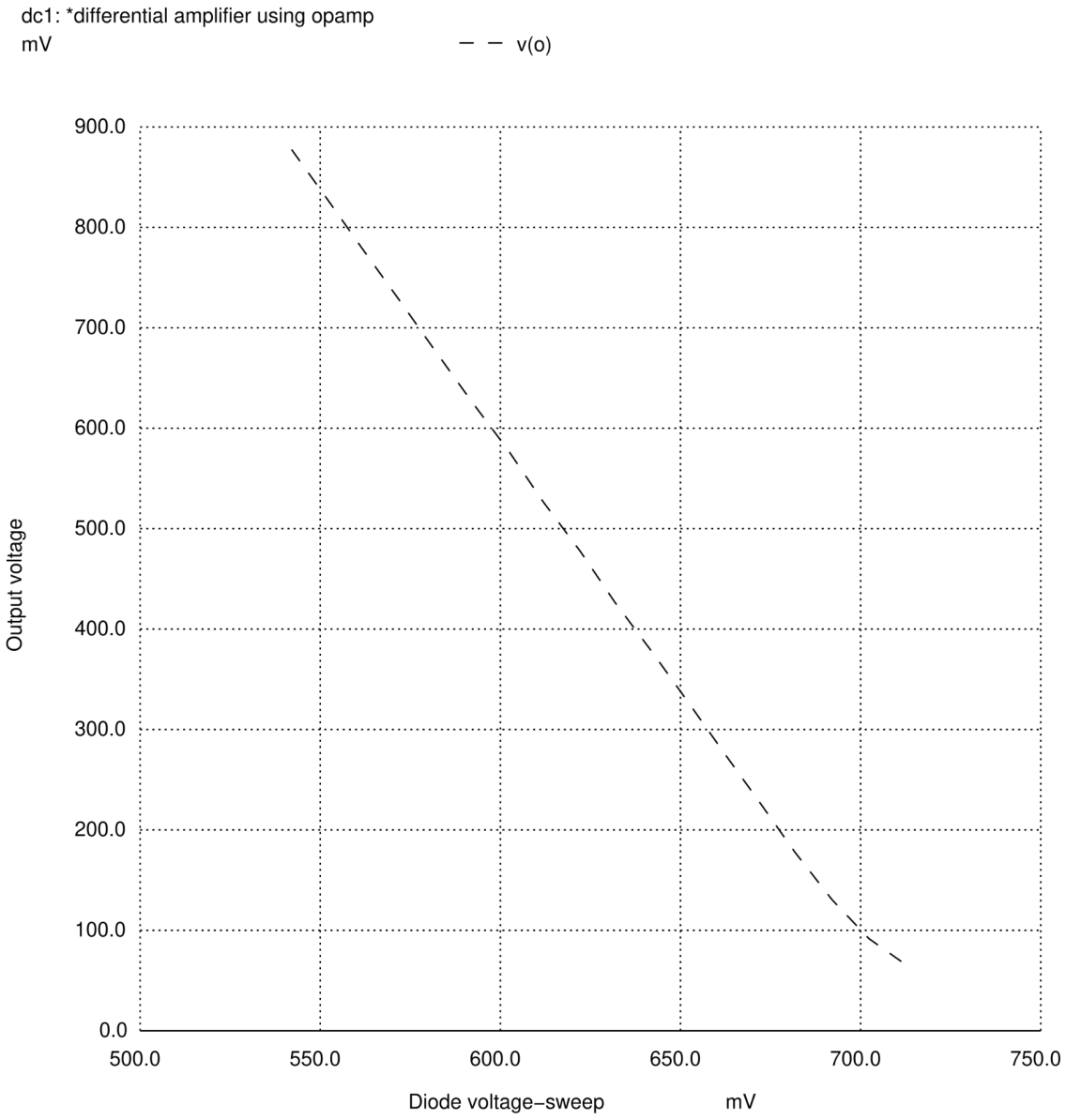
Here, inplace of DUT(diode sensor) a voltage source was used and the current corresponding to different voltages across DUT was observed.



The collector current of the BJT is constant near 5mA for different voltages at the collector.

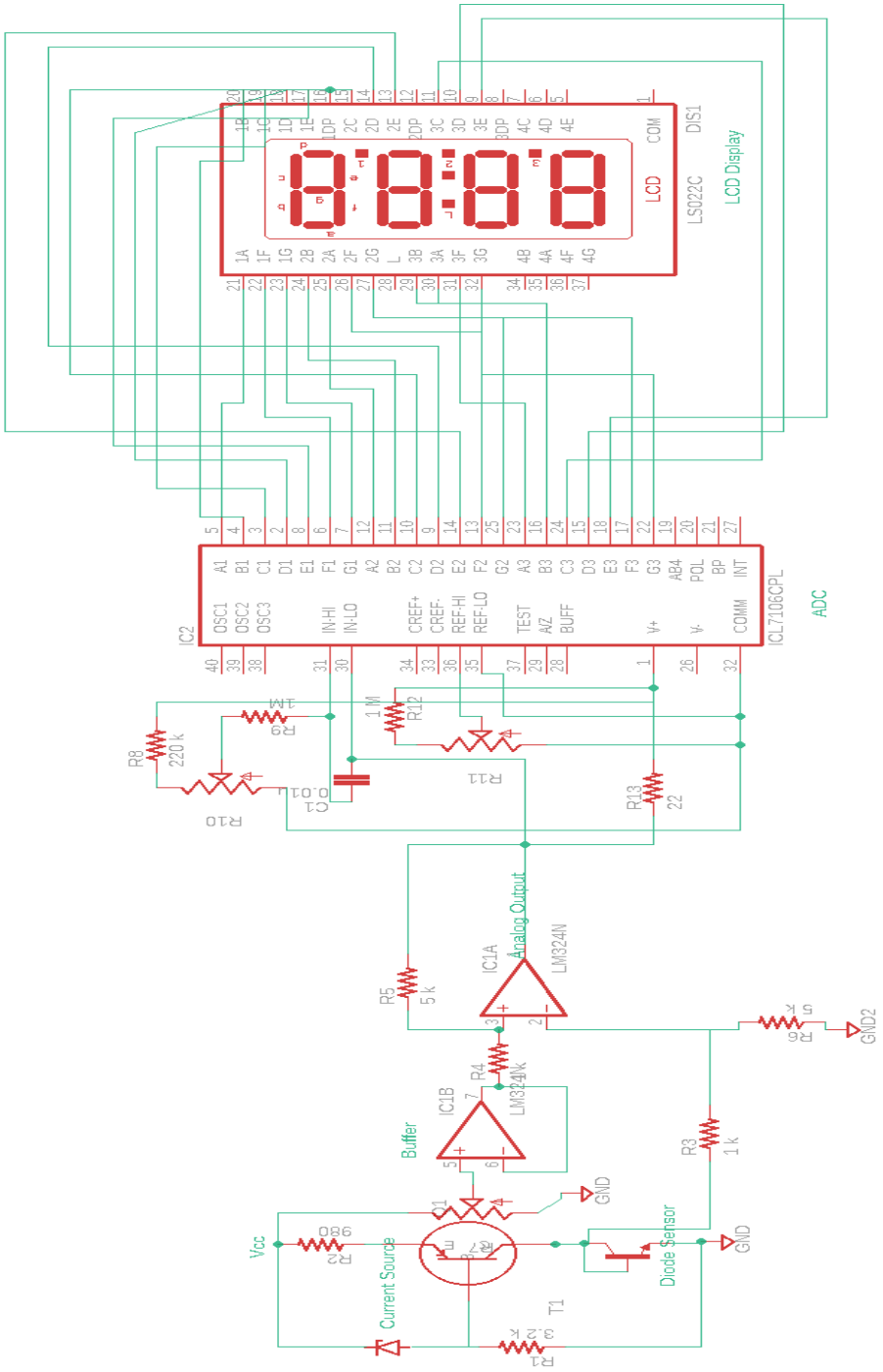
Simulation 3: Simulating the differential amplifier

Here, we are observing the output of the differential amplifier for different input voltages in the range (550mV,700mV). The V_{ref} was fixed at the voltage which we got at 0°C, i.e. 0.717V.



A differential gain of 5 can be observed here, output voltage is $5(V_{ref} - V_D)$, V_D is varied from 0.717V to 0.542V.

FINAL CIRCUIT DIAGRAM



APPENDIX

Ngspice netlists for the above simulations:

Simulation1:

```
*diode sensor

.include 2n2222.txt

q c b e Q2N2222A/ZTX
i P c dc 5m
VCC P gnd 12
v1 c b 0
v2 e gnd 0

.control

dc temp 0 100 0.1
plot v(c) ylabel 'Diode voltage'
hardcopy temp_sensor.ps v(c) ylabel 'Diode voltage'

.end
.endc
```

Simulation2:

```
*current source

.include bc547.txt
.include zener_B.txt

q1 c b e bc547a
VCC P gnd 12
RE e gnd 960
Invoking DI_1N4734A
x gnd b DI_1N4734A
RB P b 4000
VD P c 0

.control

dc vd 0.542 0.717 0.01
plot i(VD) xlabel 'Diode voltage-sweep' ylabel 'Diode current'
hardcopy current_source.ps i(VD) xlabel 'Diode voltage-sweep' ylabel 'Diode
current'
```

.endc
.end

Simulation3:

**Differential amplifier using opamp*

.include lm324.txt

invoking LM324
x NI I P N O LM324
R1 d I 1k
R2 I O 5k
R3 r NI 1k
R4 NI gnd 5k
Vref r gnd 0.717
VD d gnd 0
VCC P gnd 12
VEE N gnd 0

.control

dc VD 0.542 0.717 0.01
plot V(O) xlabel 'Diode voltage-sweep' ylabel 'Output voltage'
hardcopy Difference_amp.ps v(O) xlabel 'Diode voltage-sweep' ylabel 'Output voltage'

.endc
.end