SENSORS & AUTOMATION LAB WORK

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BRANCH :- **Metallurgy & Material Sciences**

EXPERIMENT NO. 1

Aim :- To understand the working principle of RTD
(Resistance Temperature Detector)

Objective :- 1. Study the static & dynamic characteristics of RTD
2. Study effect of various parameters on RTD performance

Theory :- A Resistance Temperature Detector is an electronic device used to determine the temperature by measuring the resistance of an electrical wire. This wire is referred to as a temperature sensor. If we want to measure temperature with high accuracy, a RTD is an ideal solution as it has good linear characteristics over a wide range of temperatures.

Calculations :-

Formula :- $R_t = R_0[1+\alpha(t-t_0)] \approx R_0[1+\alpha t]$

1] For Platinum, $\alpha = 0.00385$, Temp range = -200 to 850

R_0	Temprature	Obtained R_t
100	777	399.145
100	-79	69.585
100	848	426.48
500	316	1108.3
500	-141	228.575
500	583	1622.275

2] For Copper, $\alpha = 0.00427$, Temp range = -100 to 260

R_0	Temprature	Obtained R_t
100	55	123.485
100	101	143.127
100	4	101.708
200	-79	132.534
200	237	402.398
200	141	320.414

3] For Nickel, $\alpha = 0.00672$, Temp range = -100 to 260

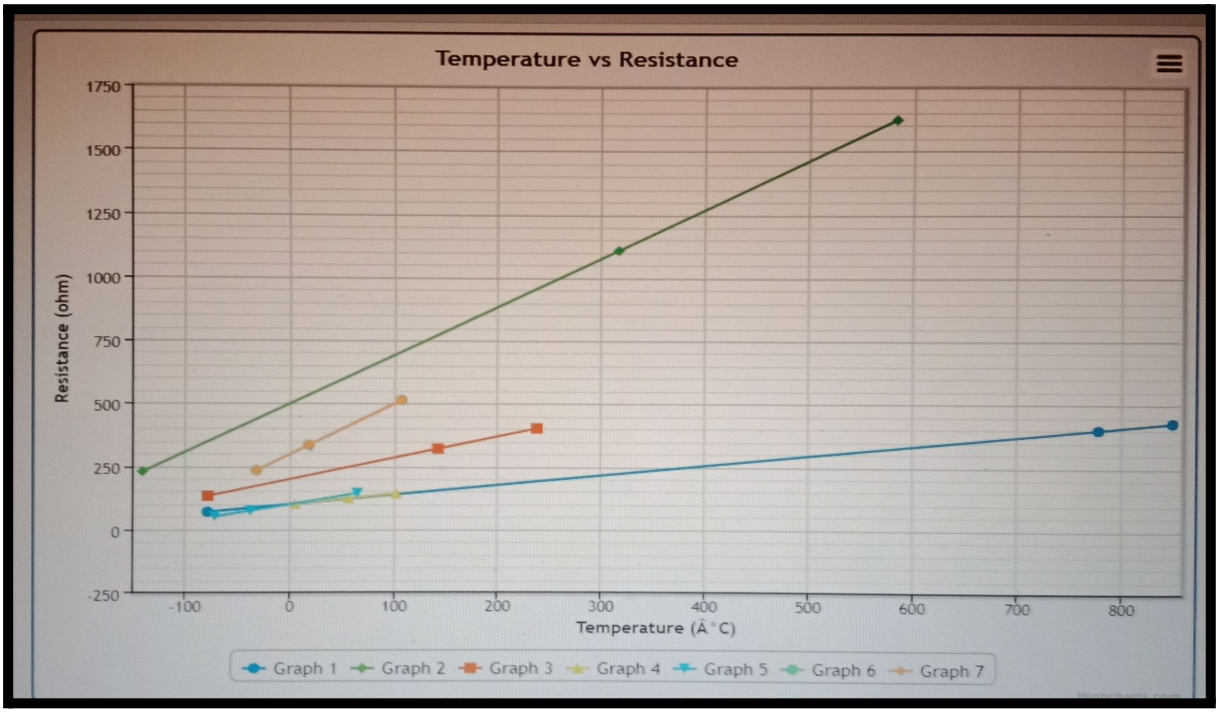
R_0	Temprature	Obtained R_t
100	-72	51.616
100	64	143.008
100	-38	74.464
300	17	334.272
300	-33	233.472
300	106	513.696

Bare :- Material ⇒ Platinum
Time constant ⇒ 1.17 seconds

Withsheath :- Material ⇒ SS 304
Thickness ⇒ 1.0 mm
Time constant ⇒ 4.13 seconds

Thermowell :- Material ⇒ SS 304
Thickness ⇒ 1.0 mm
Filling material ⇒ MgO powder
Time constant ⇒ 1.33 seconds

Graphs :-



Conclusion :- We have understood the working and structure of RTD through simulation.

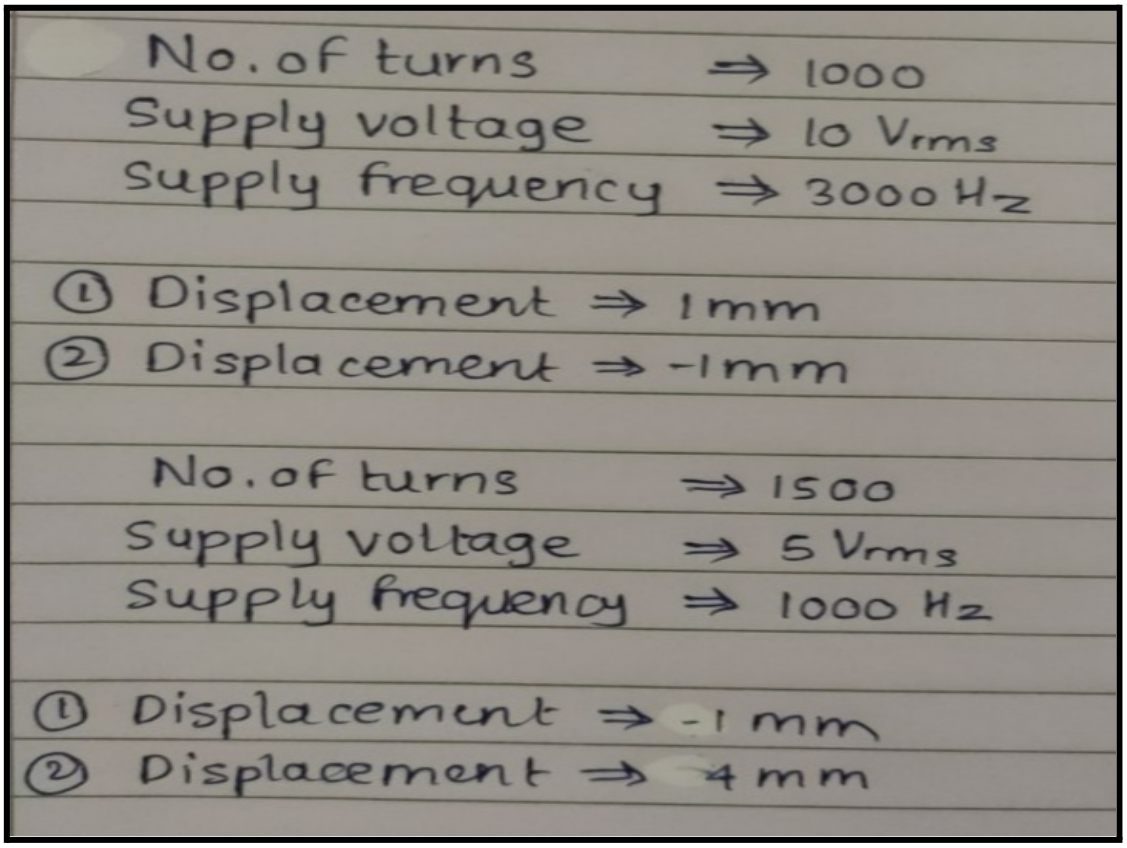
EXPERIMENT NO. 2

Aim :- To characterise the Linear Variable Differential Transformer.

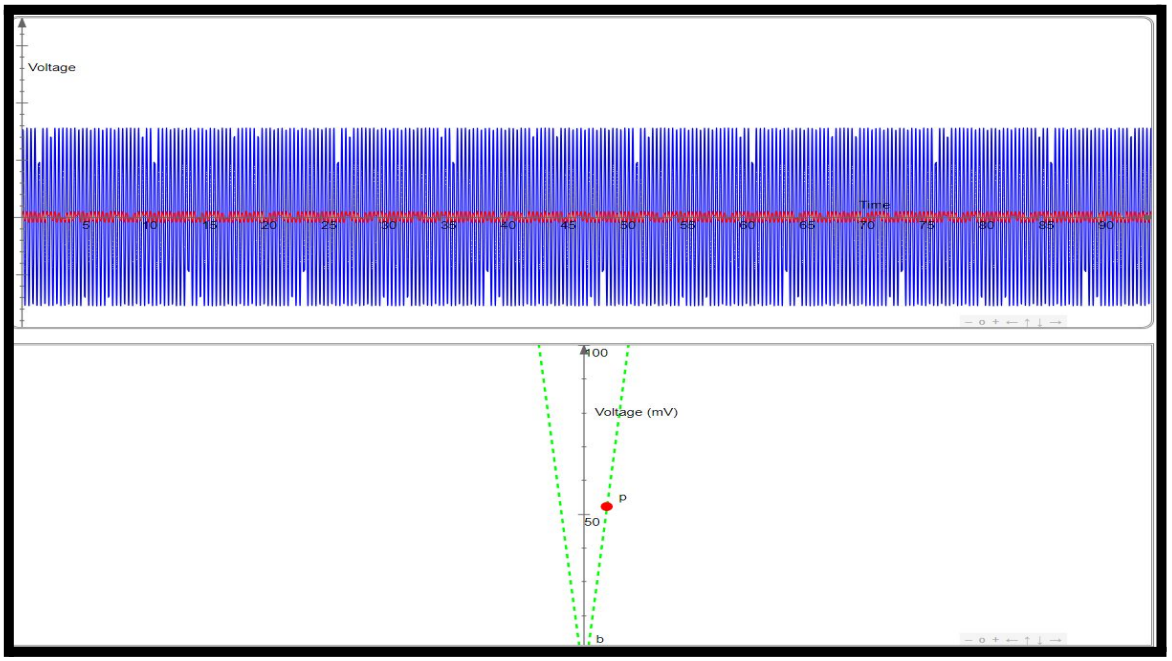
Objective :- 1. Study the relation between core displacement & output
2. Understand the effect of change in supply frequency on LVDT performance
3. Understand the effect of change in excitation (supply) voltage on LVDT performance

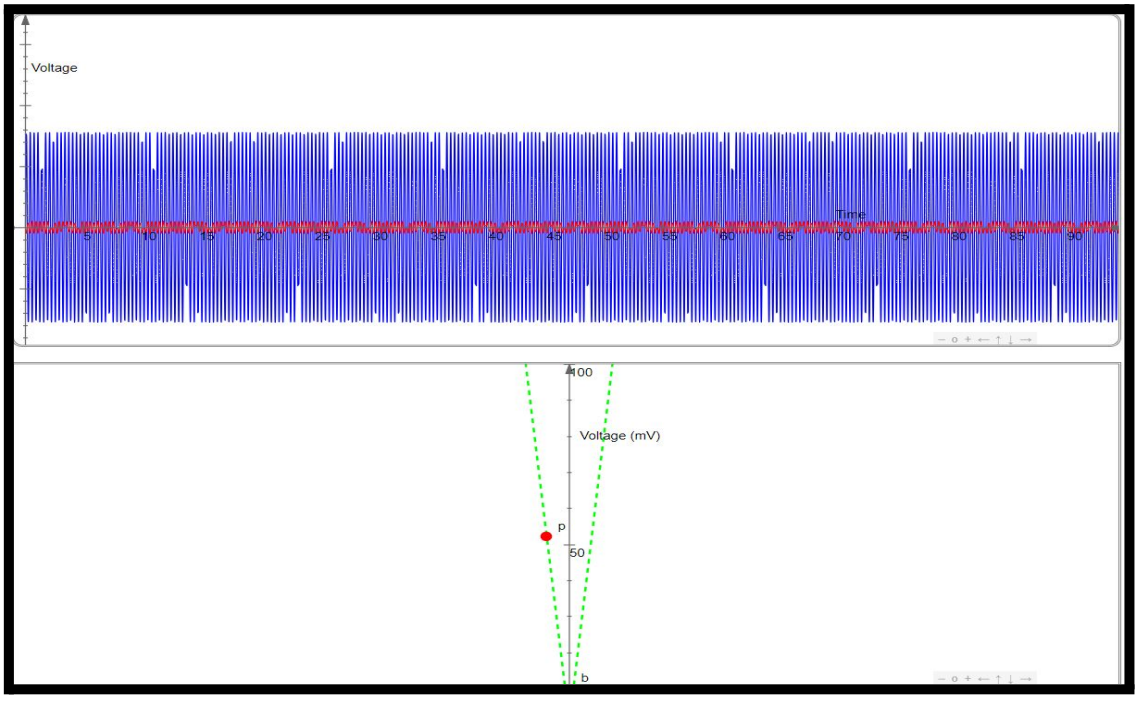
Theory :- LVDT is Linear Variable Differential Transformer. It is an electrochemical transducer It converts the rectilinear displacement of any object to which it is coupled mechanically in electrical signal proportional to it.

Calculation :-



Graphs :-


Voltage
Time
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
100
Voltage (mV)
p
50
b


Voltage
Time
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85
90
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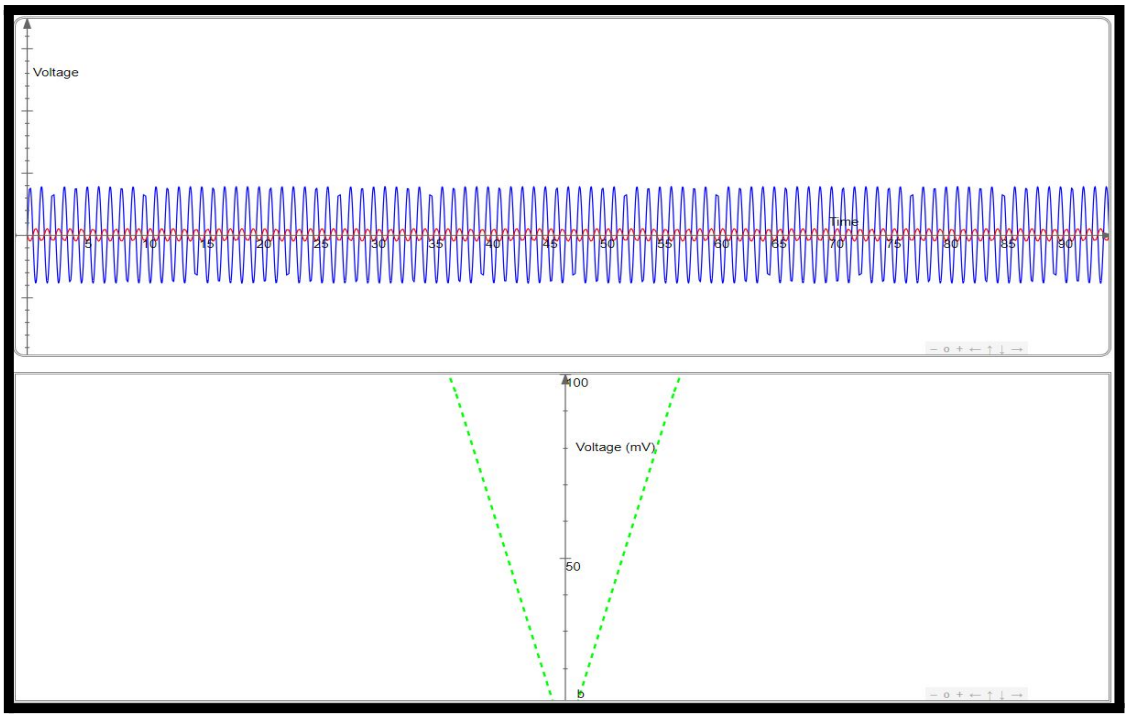
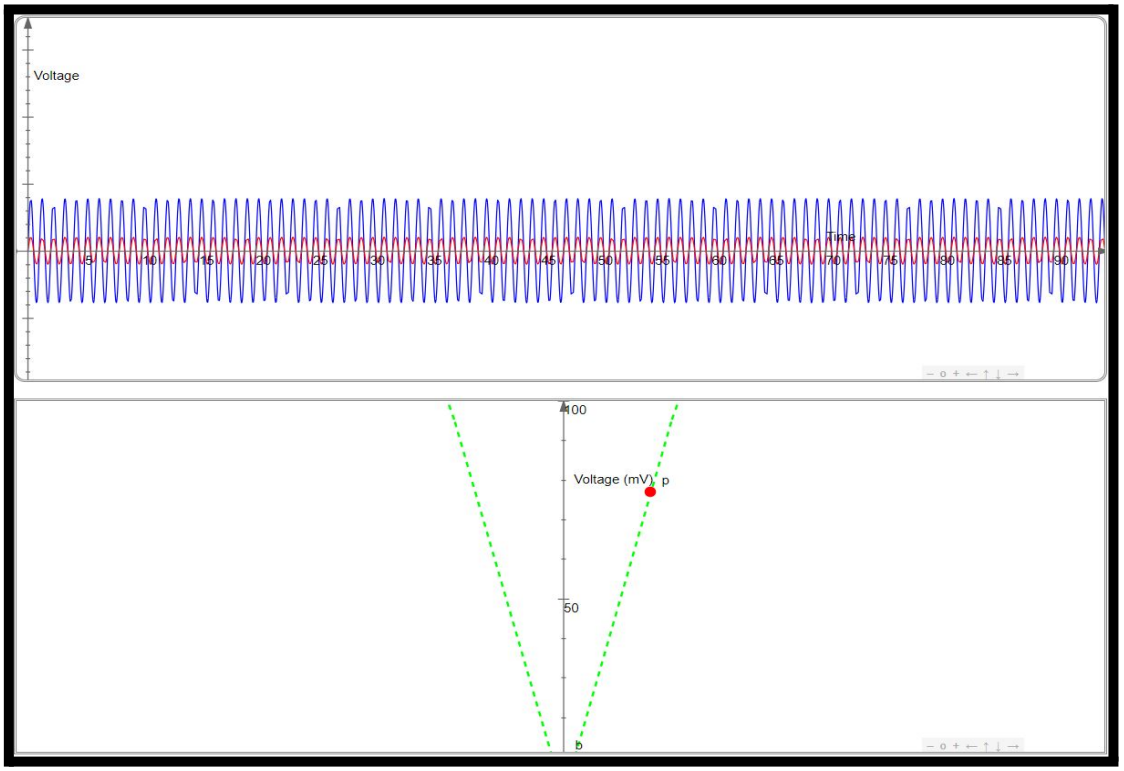
Voltage (mV)
p
50
b





Conclusion :- We have studied the working and construction of LVDT and the effect of various factors on its performance through simulation.

EXPERIMENT NO. 3

Aim :- To understand the working principle of Chemical sensors

Objective :- 1. Study the working principle of pH & conductivity sensors
2. Calibrate the pH sensor
3. Study the effect of temperature on pH measurement
4. Study effect of temperature and effect of contamination on conductivity measurement

Theory :- pH is one of the most common analyses used in the Process industry. pH is actually a measurement of the activity of hydrogen ions in the sample. pH measurement runs on a scale from 0-14, with 7.0 considered as neutral. Electrical conductivity is a measure of the ability of a solution to carry the current.

Calculation :-

- pH caliberation :- $E = \left[E_0 - 2.303 \frac{RT}{F} \times pH_c\right] \times 1000$

$$= \frac{1000 \times 2.303 \times 8.314 \times T \times pH_c}{96485}$$

- Measurement of pH :- $pH = 2.2$, $pH_c = 7 - 2.2 = 4.8$

$$\therefore E = \frac{1000 \times 2.303 \times 8.314 \times 298.15 \times 4.8}{96485}$$

$$= 283.97 \text{ mV}$$

- Effect of temprature :- lemon juice (at 298.15 K)

$pH_c = 4.8$, Output = 283.97 mV

New $T = 311$ K

$$\therefore E = \frac{1000 \times 2.303 \times 8.314 \times 311 \times 4.8}{96485}$$

$$= 296.35 \text{ mV}$$

• Measurement of conductivity

Sample ⇒ HCl, Concentration ⇒ 5% = 50,000
Equivalent weight ⇒ 36.46, Density at 25°C ⇒ 1.023
Cell constant ⇒ 1

Specific conductance = $1000.C.A_0[1 - a\sqrt{C} + bC]$

C (Normality) = $\frac{\text{conc in ppm} \times \text{density}}{1000 \times \text{equivant weight}}$

$= \frac{50000 \times 1.023}{1000 \times 36.46} = 0.65$

HCl	HCl	HCl
5%	10%	30%
1	1	1
⇒ 0.65	⇒ 1.79	⇒ 13.91

• Effect of tempriature

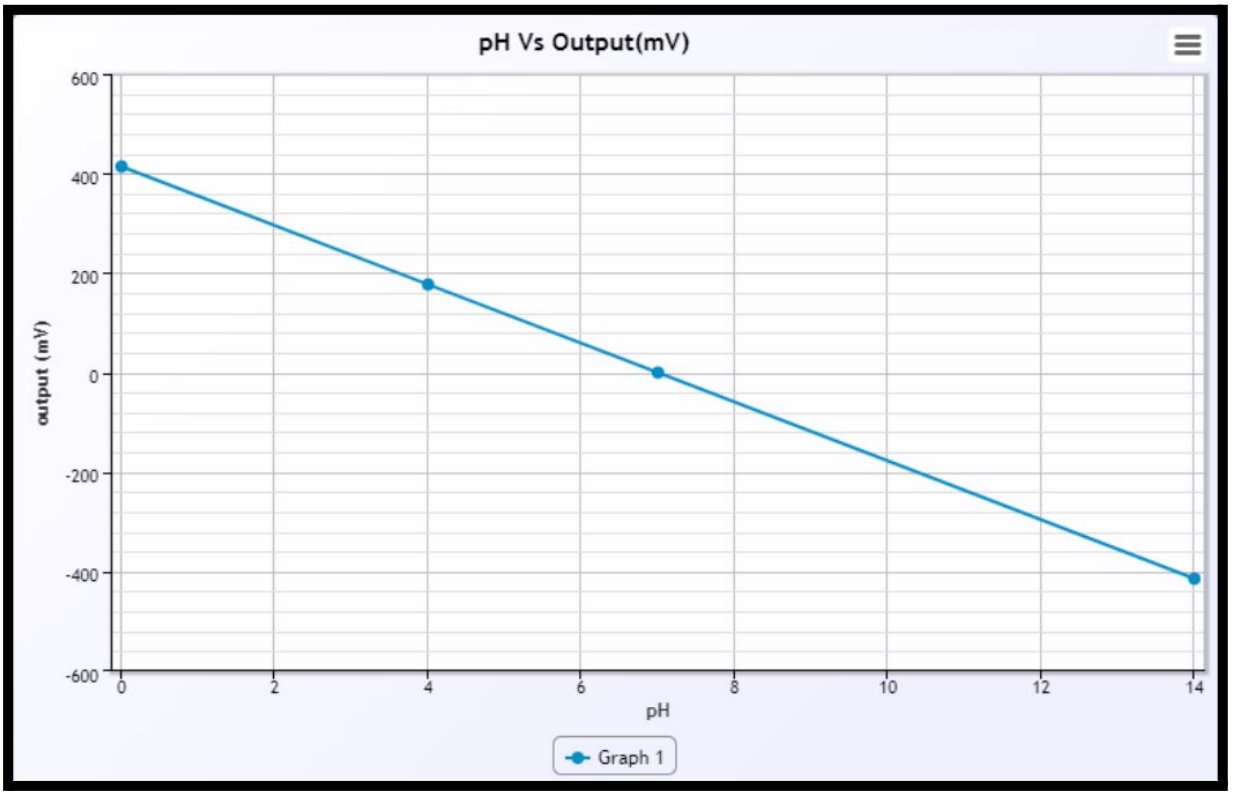
$C_T = C_R [1 + T_c (T - 25)]$, $C_R = 13.91$

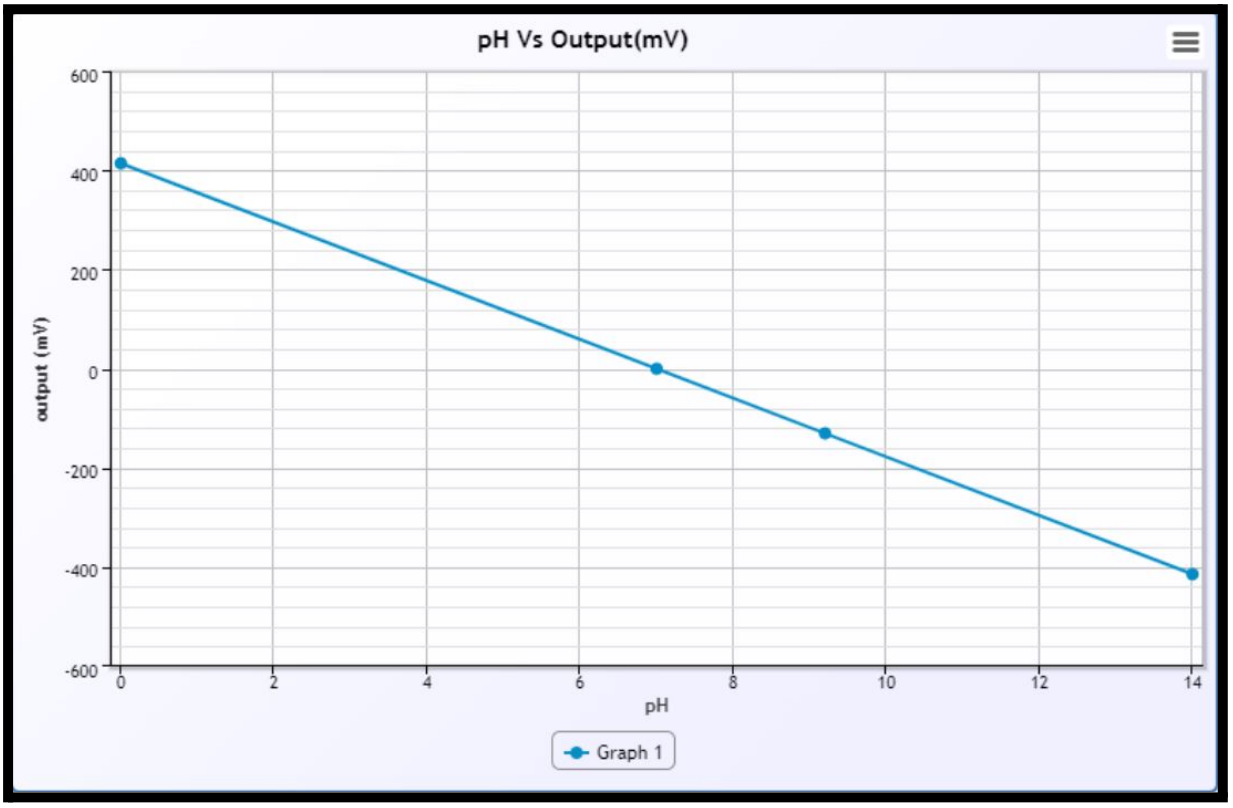
① $T = 39°C$, $\therefore C_T = (13.91)[1 + 0.0152 \times 14]$
$= 16.87$

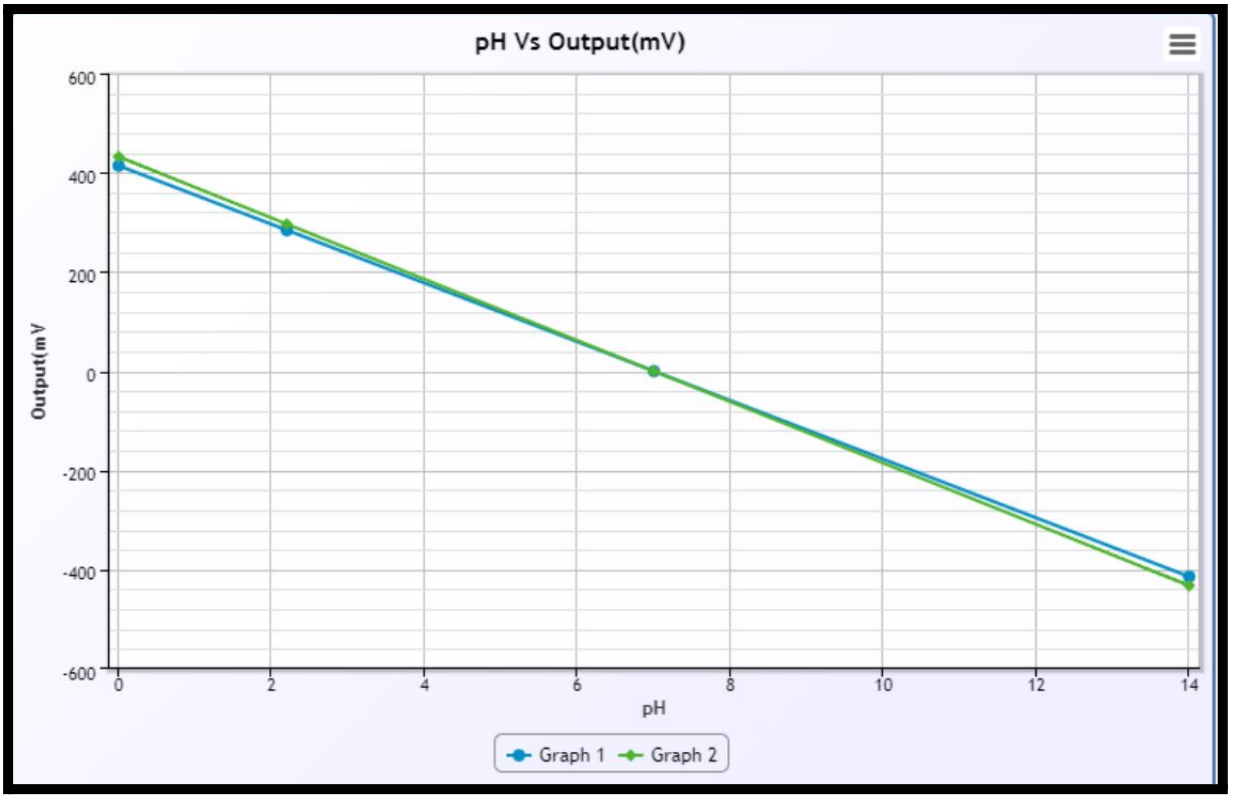
② $T = 3°C$, $\therefore C_T = 13.91[1 + 0.0152 \times 22]$
$= 9.26$

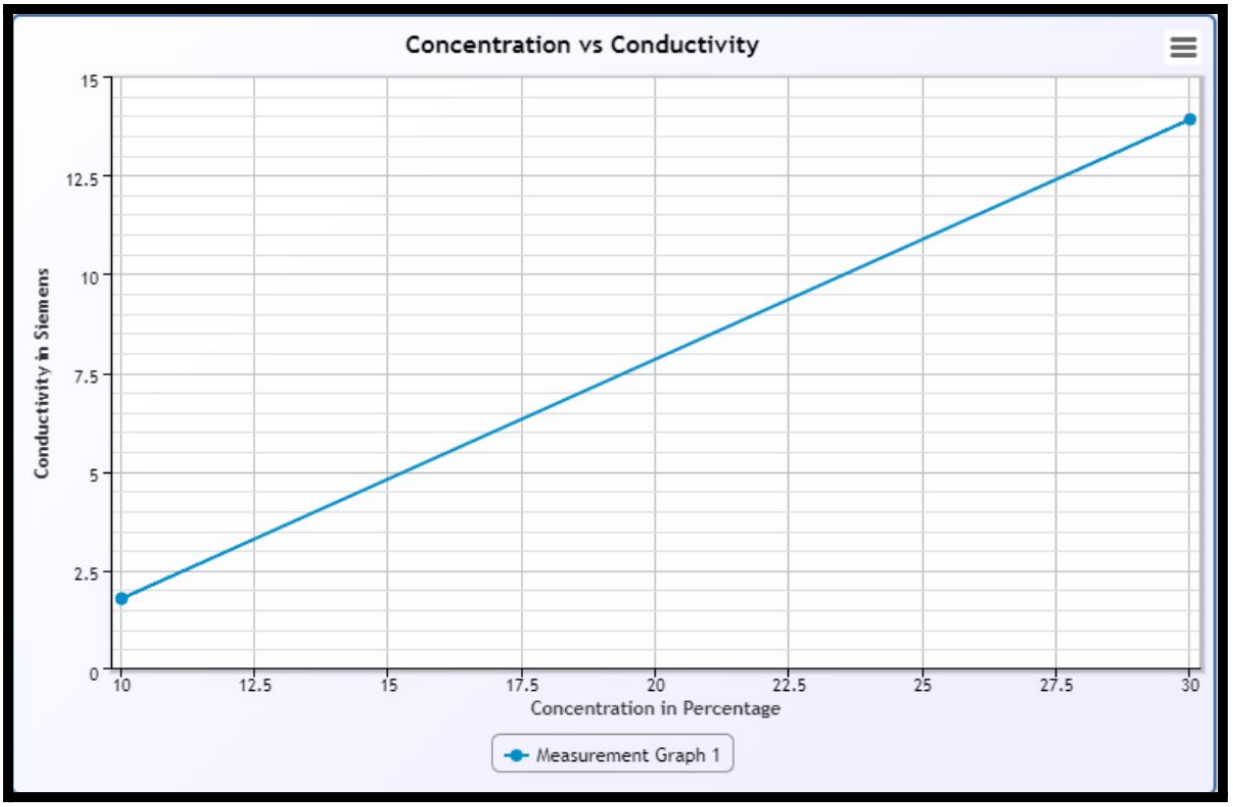
③ $T = 18°C$ $\therefore C_T = 13.91[1 + 0.0152 \times 7)]$
$= 12.43$

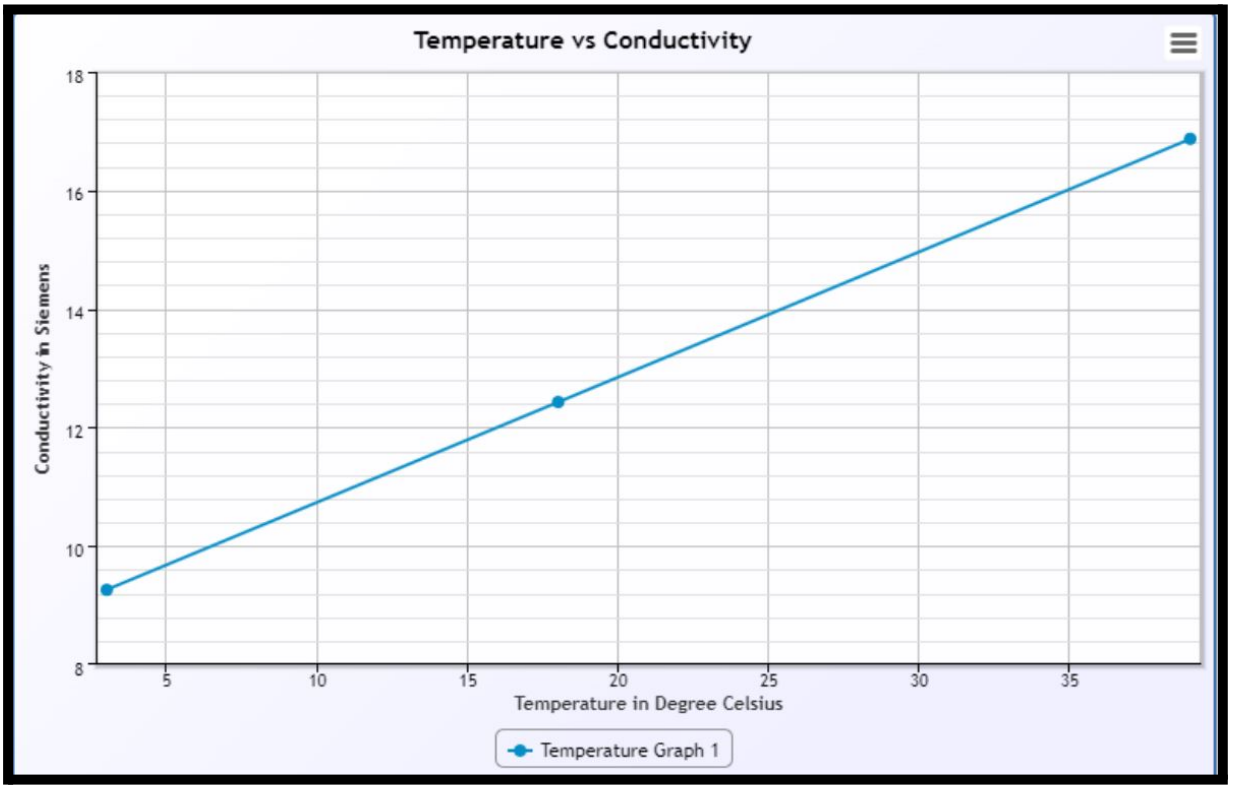
Graphs :-


pH Vs Output(mV)
600
400
200
0
-200
-400
-600
output (mV)
0
2
4
6
8
10
12
14
pH
Graph 1


pH Vs Output(mV)
600
400
200
0
-200
-400
-600
output (mV)
0
2
4
6
8
10
12
14
pH
Graph 1


pH Vs Output(mV)
600
400
200
0
-200
-400
-600
Output(mV)
0
2
4
6
8
10
12
14
pH
Graph 1
Graph 2





Conclusion :- We have studied the working principles of chemical sensors for measurement of pH value and conductivity through simulation.

EXPERIMENT NO. 4

Aim :- To measure tank level using capacitance level probe

Objective :- 1. Review various methods of level measurement
2. Understand working of capacitance level transmitter

Theory :- In industry, liquids such as water, chemicals and solvents are used in various processes. The amount of such liquid stored can be found by measuring the level of liquid in a container or a vessel. The level affects not only the quantity delivered but also pressure and rate of flow in and out of the container. Level sensors detect the level of substances like liquid, slurries, granular materials and powders. The substance to be measured can be inside a container or can be in its natural form. The level measurement can be either continuous or point values.

Calculation :-

Formula :- $C = \frac{2\pi\epsilon_0(\epsilon_1 h_1 + \epsilon_2 h_2)}{\ln(r_2/r_1)} = \frac{5.5\times10^{-11}(h_1+\epsilon_2 h_2)}{\ln(r_2/r_1)}$

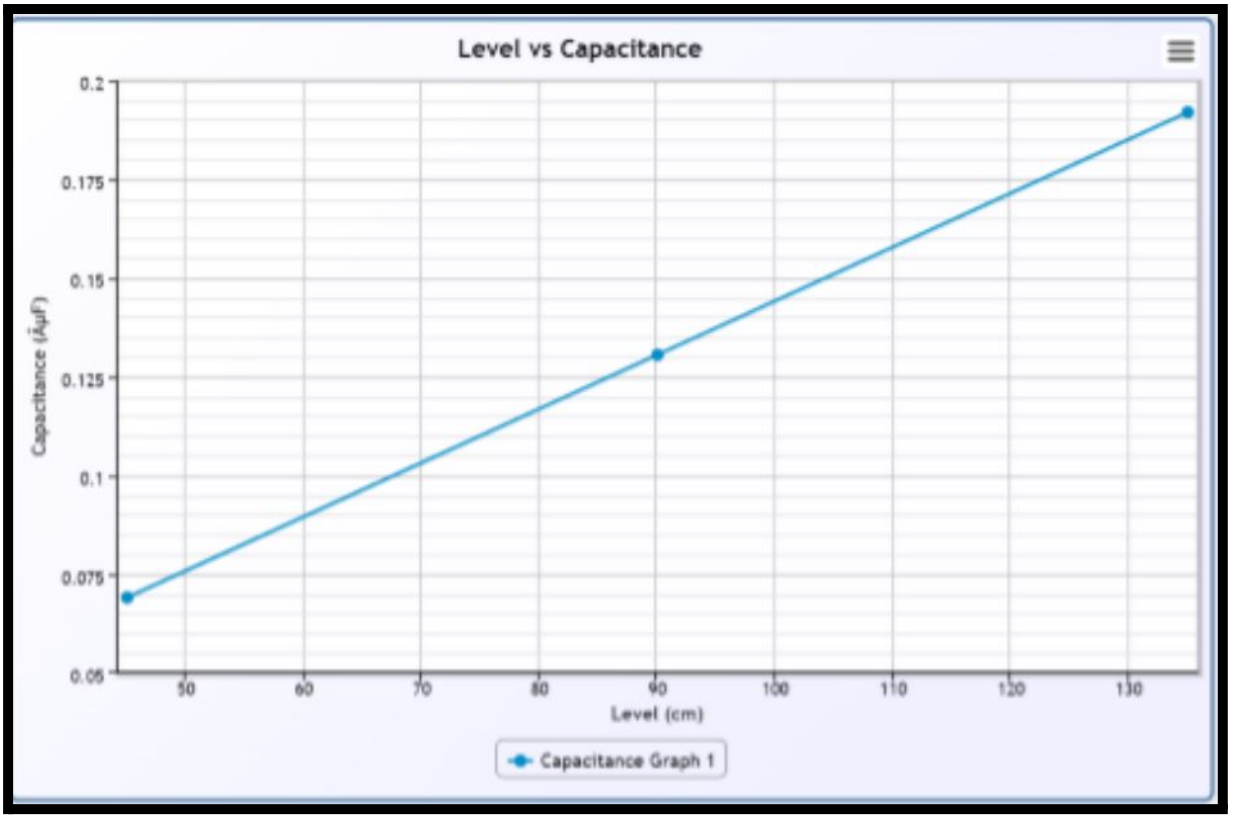
Height of tank = 500, Outer radius = 2.5
Spam value = 445, Inner radius = 0.1, Service ⇒ Water

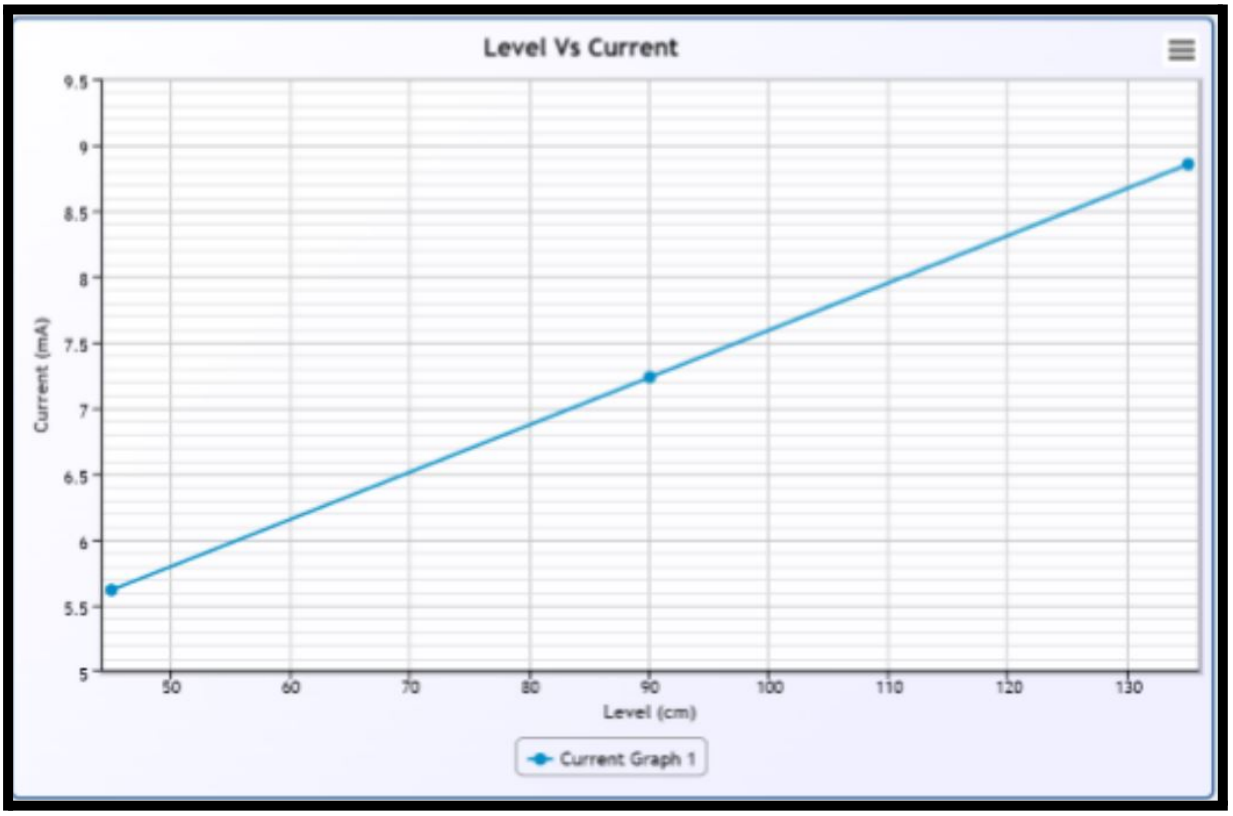
① $C = \frac{5.5\times10^{-11}[455+80\times45]}{\ln(2.5/0.1)} = 0.07\ \mu F$

② $C = \frac{5.5\times10^{-11}[410+80\times90]}{\ln(2.5/0.1)} = 0.13\ \mu F$

③ $C = \frac{5.5\times10^{-11}[365+80\times35]}{\ln(2.5/0.1)} = 0.19\ \mu F$

Graph :-





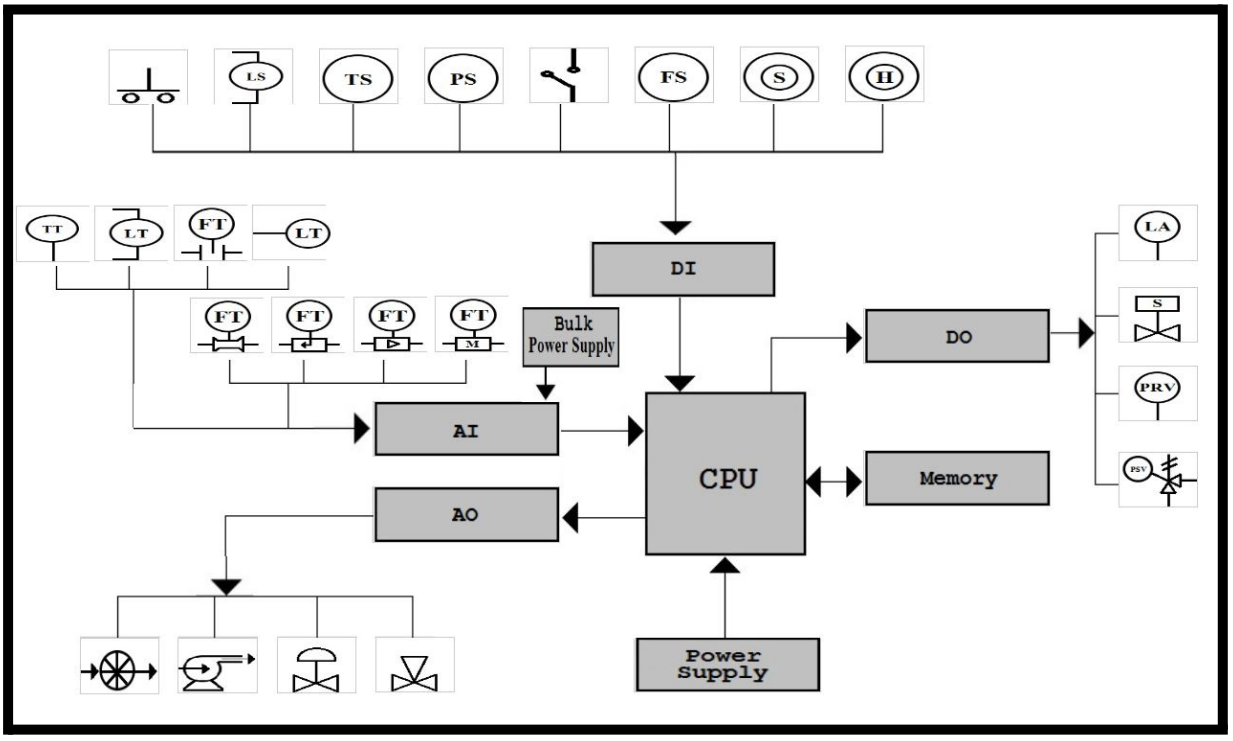
Conclusion :- We have studied the working of capacitance level probe and various level measurement methods through a simulation.

EXPERIMENT NO. 5

Aim :- To study hardware and software associated with PLC

Objective :- 1. Learn the basics and hardware components of PLC
2. Understand configuration of PLC system
3. Study various building blocks of PLC

Theory :- A Programmable Logic Controller, PLC or a Programmable controller is an electronic device used for automation of industrial processes, such as control on machinery on factory assembly lines. A programmable controller is a digitally operating electronic apparatus which uses a programmable memory for the internal storage of instructions for implementing specific functions, such a logic, sequencing, timing, counting and arithmetic to control various machines or processes through digital or analog input/output devices. Unlike general purpose computers, the PLC is designed for multiple inputs and outputs, extended temperature ranges, immunity to electrical noise and resistance to vibrations and impacts.



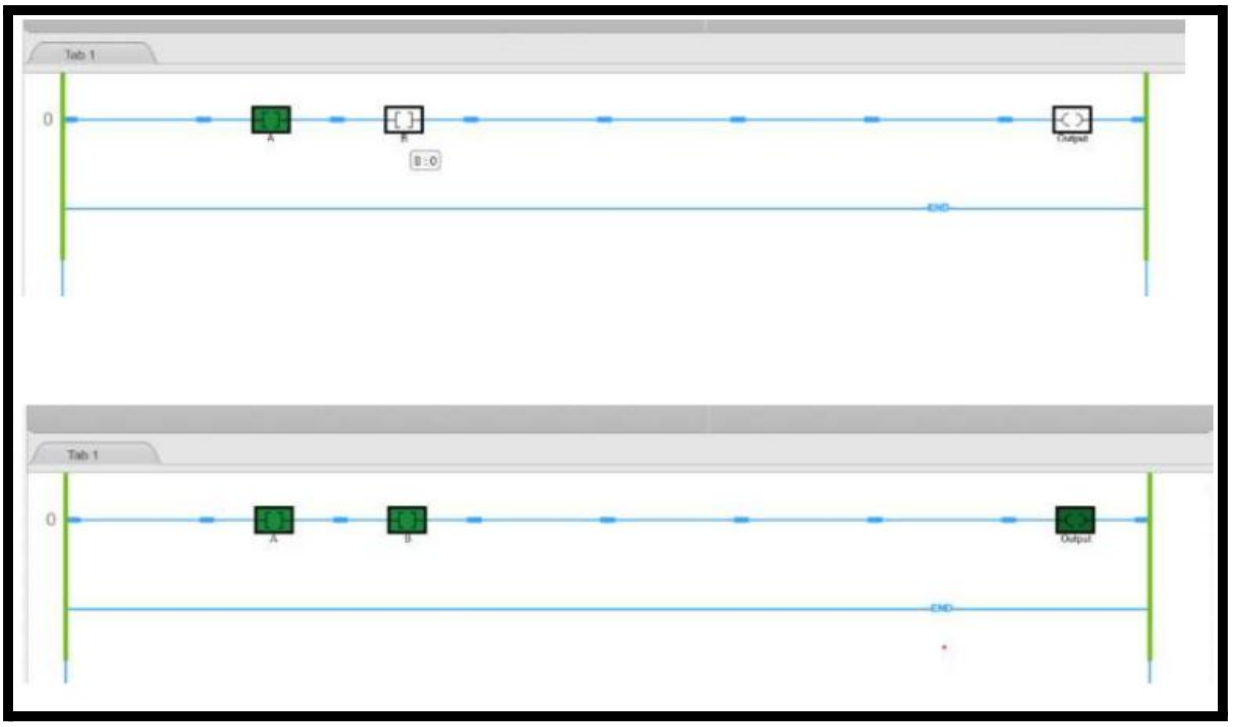
EXPERIMENT NO. 6

Aim :- To understand a simple ladder program

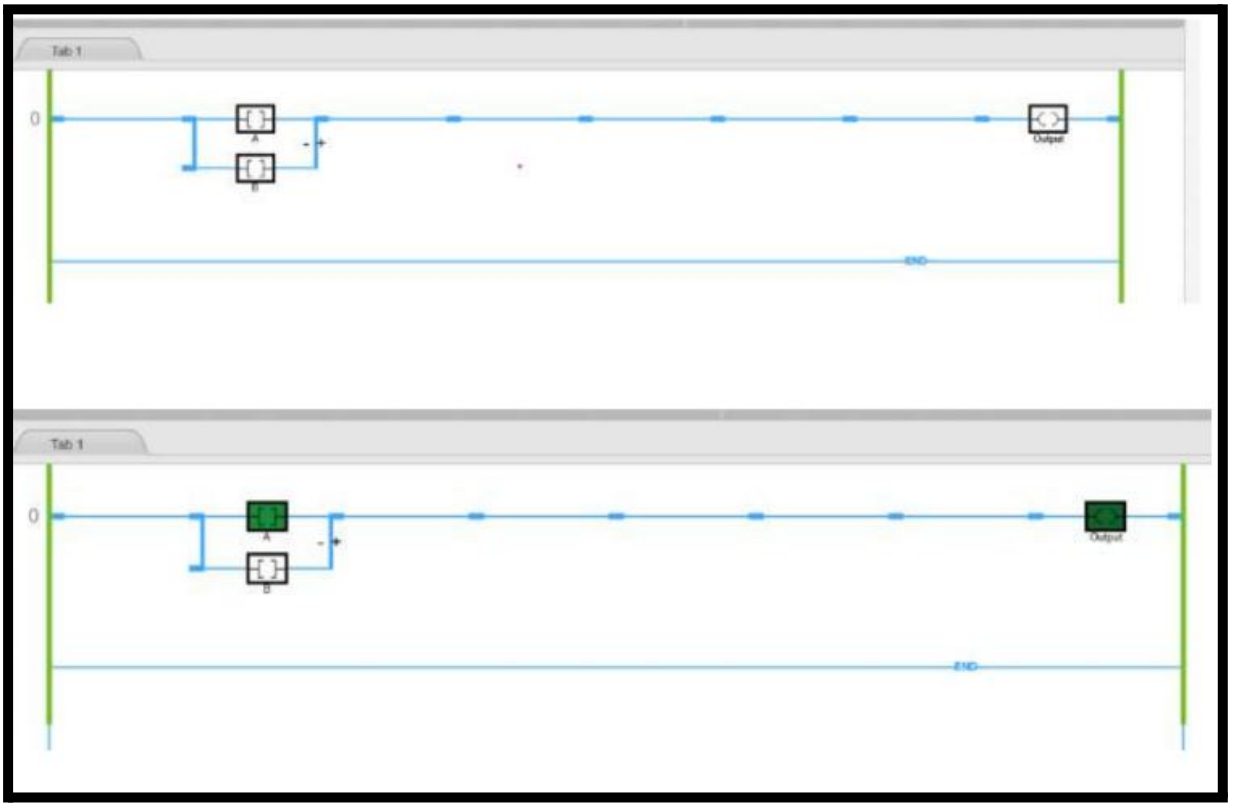
Objective :- 1. Develop a ladder using standard procedure
2. Solve the problem using ladder programming

Theory :- Ladder programming is a popular language of programming the PLCs. Ladder diagram shows the sequence of the logic execution which is presented diagrammatically. In the ladder diagram, there are two vertical lines, generally called phase, positive or neutral. Rungs which show current flow in horizontal direction are the sequence in which the logic executes. The Analogous to relay ladder has two main symbols which are contacts and output coil. Generally each rung has inputs (contacts) on the left hand side and outputs (coil) on the right hand side. These contacts and coils are called as bits of the relays. Each input and output are individual bits in I/O files. An instruction in the ladder instructs PLCs how to respond to the bits in I/O files which are stored in the memory. Input contacts are the condition area, the conditions must be fulfilled to change the status of the output coils. Each manufacturer of PLC systems has their own style of writing the instructions. Different PLCs have different instruction sets but even some common basic instructions are shared by all the PLCs. All manufacturers give different software packages for programming PLCs. Ladder is the most commonly used programming language. Prior to PLCs, relay logic was used in industry. Ladders were developed to mimic or imitate relay logic. Relay Logic / Instructions. A relay is a simple magnetic device which acts as a control switch. When the switch is on, current will flow through the coil on the iron piece. This iron core acts as an electromagnet and due to the magnetic field upper contact gets attracted towards lower one and circuit gets completed, allowing current to flow from load.

AND Gate



OR Gate



NOT Gate

Conclusion :- We have implemented the logic gates in the ladder programming using a simulator.

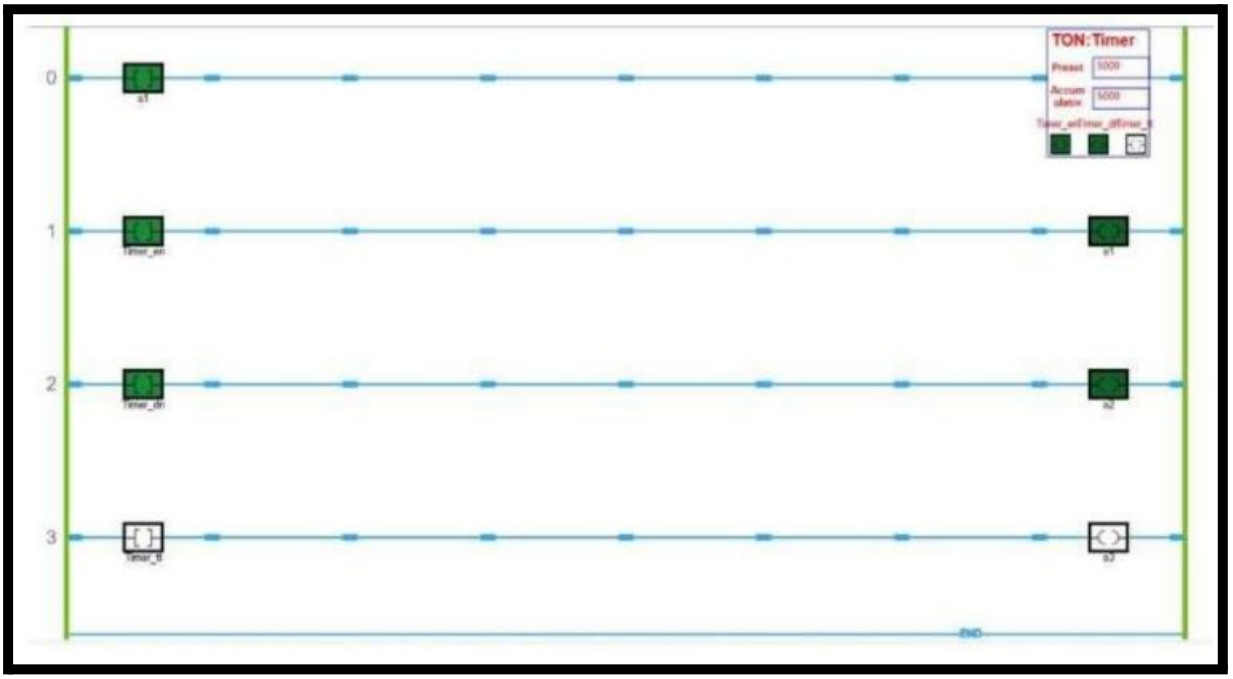
EXPERIMENT NO. 7

Aim :- To develop and application using On-Delay timer

Objective :- 1. Study the timing diagram of On-Delay timer
2. Solve the assignment of Ton timer

Theory :- It is used when an action is to begin a specified time after the input becomes true. Consider an example wherein a certain step in the manufacturing process is to begin 30 seconds after a signal is received from a limit switch. The 30 seconds delay is the ON-delay timer's preset value. The figure below shows a symbolic representation of the timer.

Result :-



Conclusion :- We have developed an application of TON Timer using the simulation.

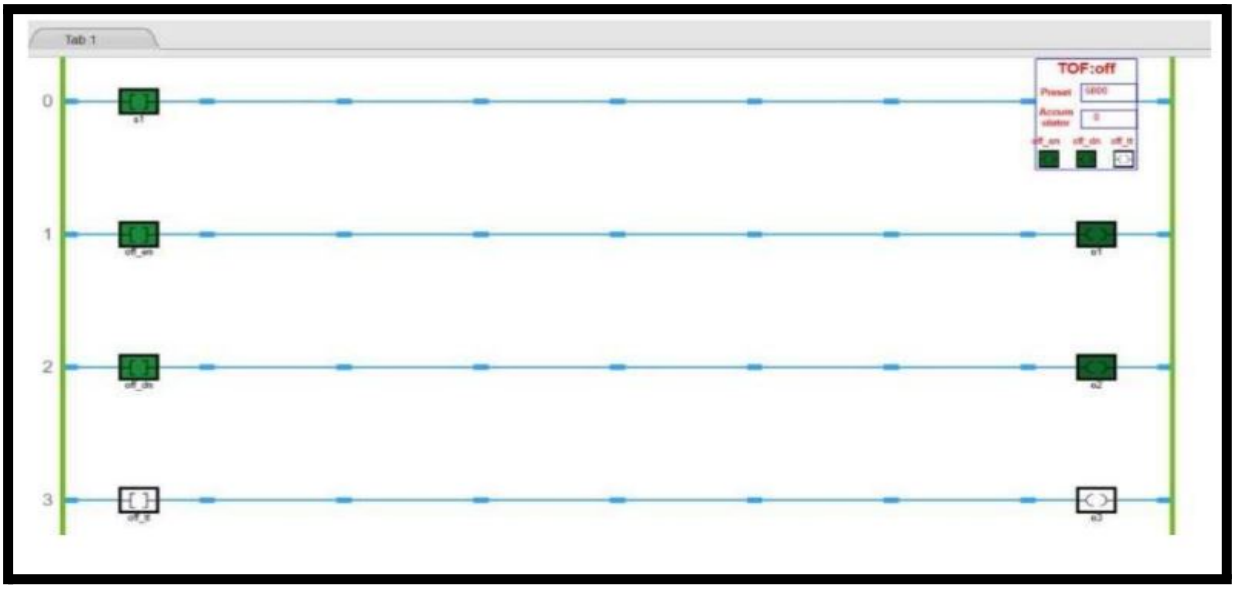
EXPERIMENT NO. 8

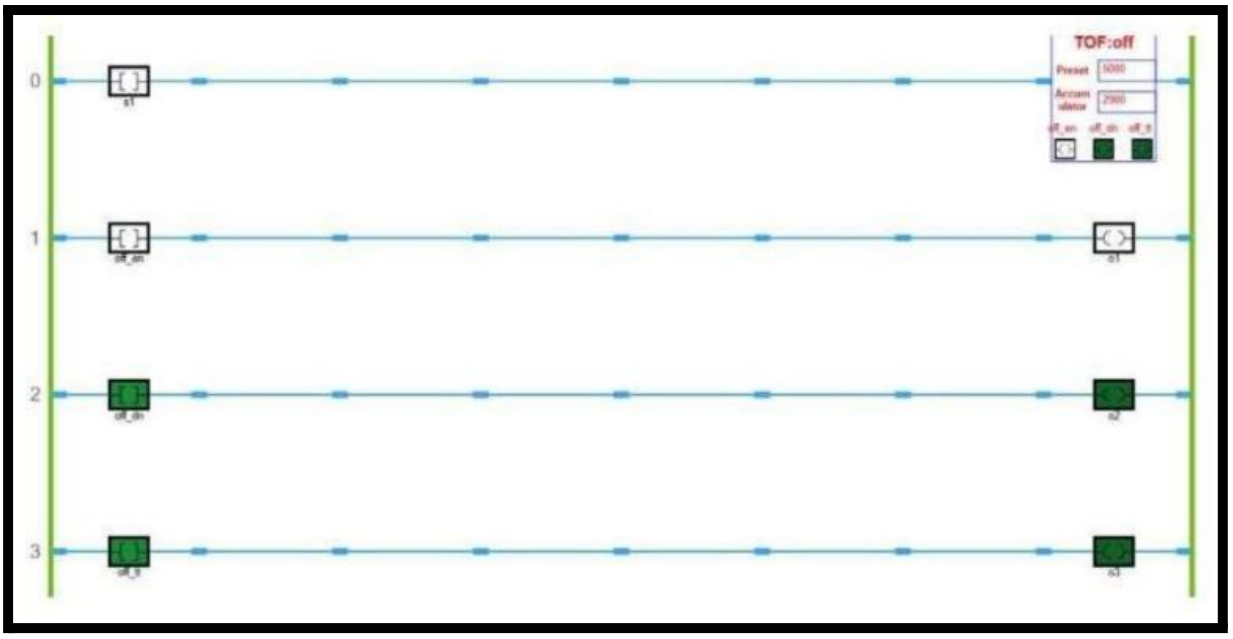
Aim :- To develop an application using Off-Delay timer

Objective :- 1. Study the timing diagram of Off-Delay timer
2. Solve the assignment of TOFF timer

Theory :- Consider an example where the contents of a storage tank are to be transferred to further process. When the low level is detected by the level switch the outlet valve is to be closed. To allow entire contents to drain out, some time delay is needed as the level switch is installed slightly above the tank bottom level. This can be achieved by using an off delay timer. Consider an example that, there is a Low level switch to a tank, and we have to close the drain valve of the tank after a 5 second delay when low level is reached. In this case this 5 seconds delay can be given using an off delay timer as we have to close the drain valve after delay.

Result :-





Conclusion :- We have developed an application of TOFF timer using the simulation.

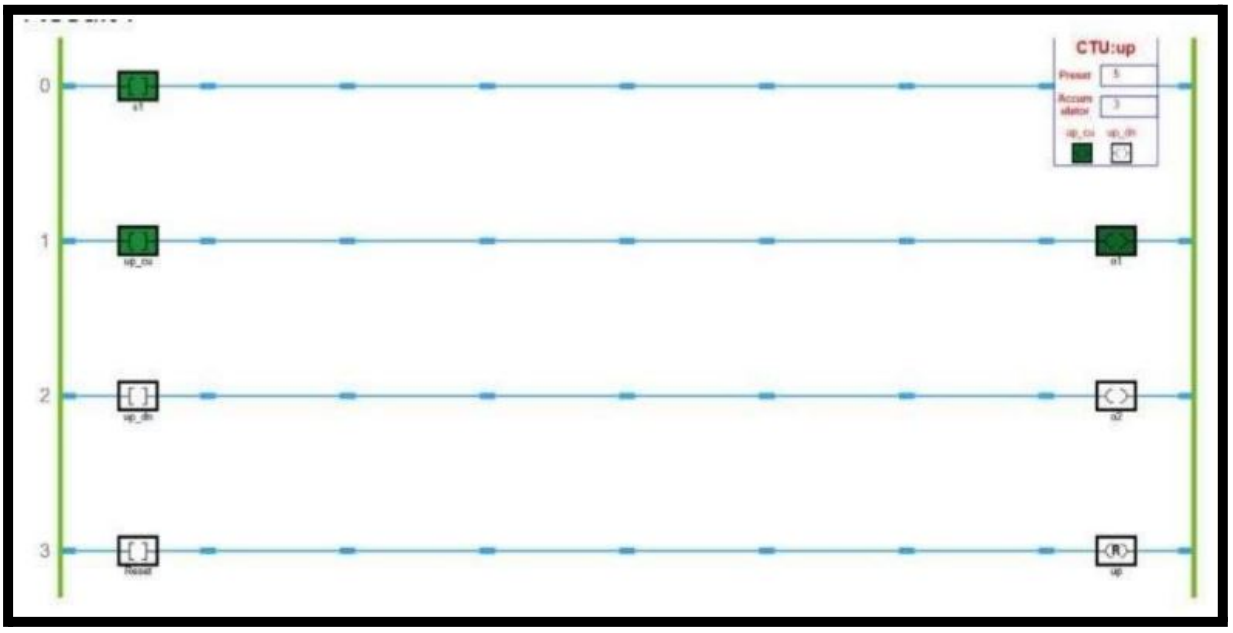
EXPERIMENT NO. 9

Aim :- To develop an application using Up/Down counter

Objective :- 1. Study counter timing diagram
2. Develop an application specific ladder program using counters

Theory :- Counters are used to count the number of objects or to count cycles of a typical process. Consider an example of a bottle filling plant, in that the counter is used to count the number of bottles filled in a particular batch. In counter instruction the accumulated value will increase only when it completes the transition from open to close or vice versa. It doesn't check how long the contact stays closed, it only looks for the transition. In the Up counter when contact change over takes place accumulator value increments by one. While in down counter when changeover takes place, the accumulator value decreases by one.

Result :-



Conclusion :- We have developed an application of Up/Down counter using simulation.