Krishnanshu Khanna
22BCT0046

30/03/2025

LABORATORY ASSIGNMENT-3

PROBLEM STATEMENT

A capacitive water level sensor measures the liquid level within a container by detecting capacitance variations resulting from height changes. This non-contact method is widely preferred for its accuracy, reliability and adaptability to different liquids.

The sensor functions as a capacitor, consisting of two conductive electrodes separated by a dielectric material. The goal is to implement an automated water level monitoring system.

SIGNIFICANCE AND REAL WORLD APPLICATION

- Industrial Applications : used in chemical plants, beverage industries and oil refineries for precise liquid level monitoring
- Agriculture:- Helps in automated irrigation systems to monitor water levels in reservoirs.
- Household Use:- Implemented in water tanks to prevent overflow and optimize water usage.
- Medical Industry:- Used in pharmaceutical liquid monitoring for quality control

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PROBLEM ANALYSIS WITH NUMERICAL EXAMPLE:-

The capacitance (C) of a parallel plate capacitor is given by:

$$C = \frac{\varepsilon_0 \varepsilon_r A}{d}$$

where
- ε_r = Relative permittivity of medium (1 for air, ~80 for water)
- ε_0 = Vaccum permittivity (8.854×10^{-12} F/m)
- A = Electrode area (m^2)
- d = Distance between electrodes (m)

Example calculation

- Given $A = 0.01 m^2$
  $d = 0.001 m$
- with air $C_{air} = \frac{8.854 \times 10^{-12} \times 0.01}{0.001} = 0.8854 pF$
- with water $C_{water} = \frac{8.854 \times 10^{-12} \times 0.01 \times 80}{0.001} = 70.83 pF$

Characteristics

Sensor Type	Formula	Accuracy Error	Annual Drift
Capacitance	$C = \varepsilon_0 \varepsilon_r A/d$	±0.5 pF	0.6%

As the relative water level increases the hygroscopic material absorbs more water vapor, increasing dielectric constant ε_r. This increase leads to a higher capacitance, which can be measured and correlated to ambient humidity.

Control Logic:-

1) Sensor Initialization - System initializes & sets baseline capacitance value.
2) Measurement-
   - Apply an AC signal to electrode.
   - Measurement capacitance changes over time
3) Threshold Detection-
   - If capacitance exceeds air threshold, detect water presence.
   - Convert capacitance values to water level readings
4) Alert System:-
   - If water level is too low/high, trigger alarm.
   - Send data for realtime monitoring & automation

Pseudocode:-

```
Start / Begin
Initialize sensor parameters and csv file
Set threshold capacitance for air and water
while system is running -
    Read capacitance value
    If capacitance > threshold for air
        Calculate water level
        Display water level
        If water level crosses set limits -
            trigger alarm
    Store data to log
End
```

Folder Structure

```
LA3-22BCT0046
  > data
    LA3-22BCT0046.c      U
    LA3-22BCT0046.exe    U
    LA3-22BCT0046.h      U
    LA3-22BCT0046.py     U
```

```c
// Define structure for Magneto Sensor
typedef struct {
    int id;
    char type[20];
    float last_value;
    float resistance;
} MagnetoSensor;
```

```c
// Define structure for Capacitive Sensor
typedef struct {
    int id;
    char type[20];
    float last_value;
    float capacitance;
} CapacitiveSensor;
```

```c
void init_capacitive(CapacitiveSensor *sensor, int id) {
    sensor->id = id;
    sensor->capacitance = (rand() % 60) + 10;
}
void init_magnetoresistance(MagnetoSensor *sensor, int id) {
    sensor->id = id;
    sensor->resistance = (rand() % 100) + 20;
}
```

CSV FILE

```c
FILE *file = fopen("./data/LA3-22BCT0046_DATA.csv", "w");
if (!file) {
    printf("Error opening CSV file!\n");
    return 1;
}
```

Logging

```c
for (int t = 0; t < N_READINGS; t++) {
    float capacitance = get_capacitance(&c_sensor, 4);
    float magnetoResistance = get_magneto_resistance(&m_sensor, 4);

    char action[20] = "None";
    if (capacitance > 35) {
        snprintf(action, sizeof(action), "Soil is wet");
    } else if (capacitance < 30) {
        snprintf(action, sizeof(action), "Soil is dry");
    }

    log_to_csv(file, t, capacitance, magnetoResistance, action);
}
```

Testcase:1

No of Readings 100

```
f:\sensorsLabLA1\LA3-22BCT0046>cd "f:\sensorsLabLA1\LA3-22BCT0046\" && gcc LA3-22BCT0046.c
Input number of sensor readings needed: 100
100 sensor data logged successfully!

f:\sensorsLabLA1\LA3-22BCT0046>
```

```
Time,Capacitance,MagnetoResistance,Action
0,60.00,43.00,Soil is wet
1,60.00,39.00,Soil is wet
2,59.00,37.00,Soil is wet
3,60.00,38.00,Soil is wet
4,58.00,37.00,Soil is wet
5,59.00,39.00,Soil is wet
6,60.00,43.00,Soil is wet
7,60.00,46.00,Soil is wet
8,60.00,47.00,Soil is wet
9,56.00,48.00,Soil is wet
10,52.00,51.00,Soil is wet
```

Testcase:2

No of Readings 50

```
f:\sensorsLabLA1\LA3-22BCT0046>cd "f:\sensorsLabLA1\LA3-22BCT0046\" && gcc LA3-22BCT0046.c
Input number of sensor readings needed: 50
50 sensor data logged successfully!
```

```
Time,Capacitance,MagnetoResistance,Action
0,23.00,55.00,Soil is dry
1,26.00,59.00,Soil is dry
2,28.00,59.00,Soil is dry
3,29.00,57.00,Soil is dry
4,27.00,61.00,Soil is dry
5,29.00,65.00,Soil is dry
6,26.00,68.00,Soil is dry
7,28.00,68.00,Soil is dry
8,29.00,68.00,Soil is dry
9,31.00,72.00,None
10,35.00,70.00,None
11,35.00,69.00,None
12,38.00,71.00,Soil is wet
13,42.00,74.00,Soil is wet
14,39.00,78.00,Soil is wet
15,41.00,77.00,Soil is wet
16,40.00,77.00,Soil is wet
17,41.00,78.00,Soil is wet
18,37.00,77.00,Soil is wet
19,35.00,76.00,None
20,31.00,77.00,None
21,28.00,74.00,Soil is dry
```

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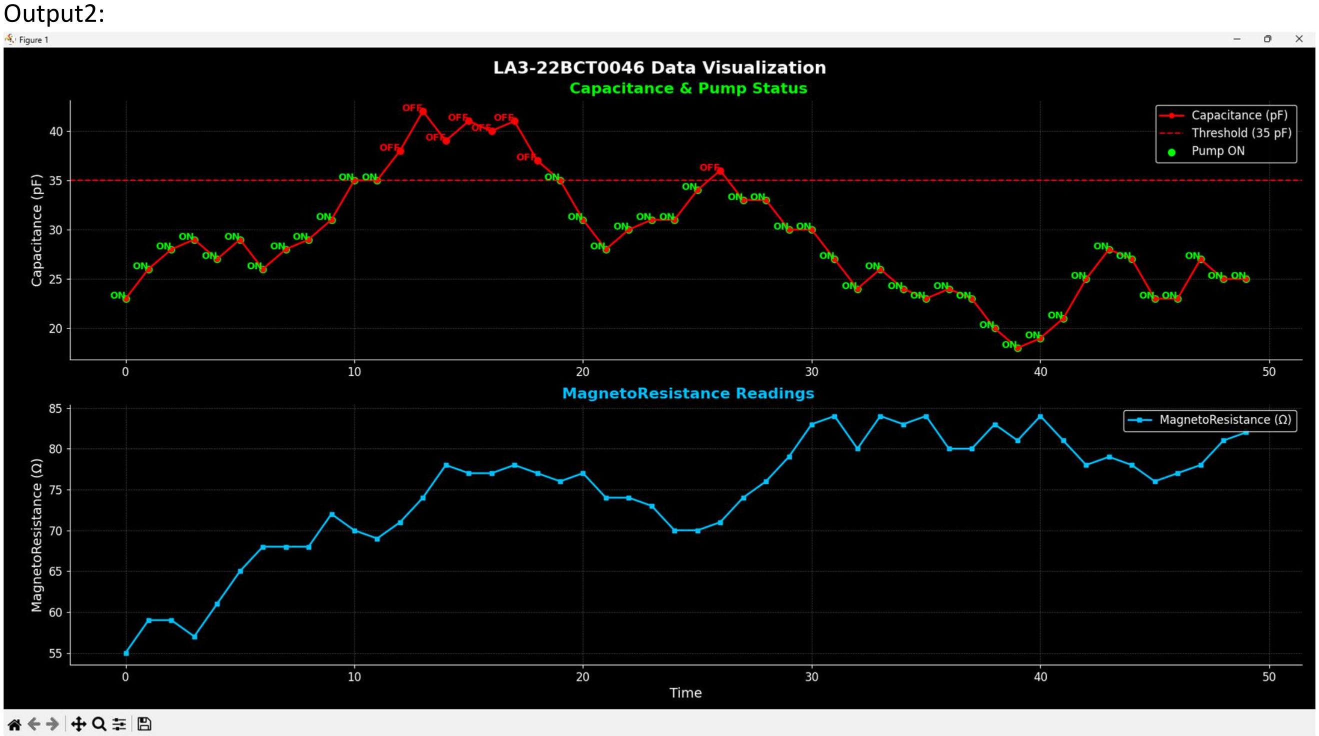
Output1:

Output2:



RESULTS AND ANALYSIS

→ The experimental results showed that capacitance increased significantly as water level rose.

→ Sensor was able to detect minimum and maximum water levels with high accuracy.

→ Graphical analysis in Python confirmed a linear relationship between water level and capacitance.

The capacitive water level sensor effectively provides real-time monitoring of liquid levels with high accuracy & reliability. The system is ideal for industrial, agricultural and household applications due to its non-contact nature and resistance to contamination & corrosion.