LabVIEW based Water Level Measurement Using Parallel Plate Capacitive Sensor

A Project report submitted in partial fulfilment

Of the requirements for the degree of B. Tech in Electrical Engineering

By

Amrita Singha Roy (EE2015/031)
University Roll No: 11701615005
Nitin Kumar (EE2015/016)
University Roll No: 11701615027
Somnath Dutta (EE2015/027)
University Roll No: 11701615053
Arindam Naskar (EE2015/051)
University Roll No: 11701615008

Under the supervision of

Dr. Debasish Mondal, Associate Prof. & HoD
Dept. of Electrical Engineering

Department of Electrical Engineering

RCC INSTITUTE OF INFORMATION TECHNOLOGY

CANAL SOUTH ROAD, BELIAGHATA, KOLKATA – 700015, WEST BENGAL

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Name and Signature of the Student

Place:

Date:

CERTIFICATE

<u>To whom it may concern</u>

This is to certify that the project work entitled "**LabVIEW Based Water Level Measurement Using Parallel Plate Capacitive Sensor**" is the bona fide work carried out by **Amrita Singha Roy (EE2015/031)**, **Nitin Kumar (EE2015/016)**, **Somnath Dutta (EE2015/027)** and **Arindam Biswas (EE2015/51)**, students of B.Tech in the Dept. of Electrical Engineering, RCC Institute of Information Technology (RCCIIT), Canal South Road, Beliaghata, Kolkata-700015, affiliated to Maulana Abul Kalam Azad University of Technology (MAKAUT), West Bengal, India, during the academic year 2018-19, in partial fulfillment of the requirements for the degree of Bachelor of Technology in Electrical Engineering and that this project has not submitted previously for the award of any other degree, diploma and fellowship.

_____   _____

Signature of the Guide   Signature of the HOD

Name: Name:

Designation: Designation:

_____

Signature of the External Examiner

Name:

Designation:

: Table of Content :

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: *List of Nomenclature*:

h = height of the capacitor plate

b = width of the capacitor plate

l = distance between the plates of the capacitor

A = area of the Aluminum plates of the capacitor

C = capacitance value

x = water Level

ε = permittivity

ε_0 = permittivity of vacuum

ε_r = relative permittivity

S = sensitivity of the sensor

ΔC = change in capacitance

ΔA = change in area of the capacitor

Δx = change in water level

f = input frequency supply

V_{ol} = output voltage of linearization circuit

V_{il} = ac input voltage

V_{oa} = amplifier output voltage

V_{dc} = Sensor output DC Voltage

R_l = input resistor of the Op-Amp

R_{fa} = feedback resistor of the Op-Amp

R_{ia} = feedback resistor input amplifier

: *List of Acronyms*:

LabVIEW: Laboratory Virtual Instrument Engineering Workbench

DC/dc : Direct Current

nF : nano Farad

AC/ac: Alternate Current

cm: centimeter

m: meter

PVC: Poly Vinyl Chloride

Op-Amp: Operational Amplifier

NI : National Instruments

IP: Internet Protocol

AI: Analog Input

VI: Virtual Instruments

: *List of Table*:

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Abstract

In this project capacitive sensor for water level detection has been fabricated. It has, typically, high-impedance sensor, particularly at low frequencies, as clear from the impedance (reactance) expression for a capacitor. In this project, water level sensor based on capacitive principle created using two resin coated Aluminum plates with height (h), width (b) and distance (l) between two plates of 40 cm, 1.1 cm and 4 mm respectively. 5 V_{p-p} 5KHz AC signal is used as input signal for the system. Capacitance between two plates is proportional to water level. Hence, it can be used to determine water level from electrical characteristics as it is inversely proportional to the sensor impedance. Linearization, inverting amplifier and rectifier circuits are used as signal conditioning for the system based on conducted experiment, the relationship between water level (x), capacitance (C) and output voltage (V_{dc}) can be expressed as $C(x) = 1.926x + 0.0097$ nF and $V_{dc}(x) = 8.36x + 0.041$ V. The sensor output after signal conditioning is connected to the LabVIEW for display.

1. Introduction:

Measurement of liquid level inside a container with various methods has been developed [1] [2]. Liquid level measurement can be utilized from the characteristic of the liquid itself; such as permittivity, permeability, conductivity, et cetera. One type of sensor which developed for liquid level measurement is capacitive sensor. Capacitive sensor can be categorized as reactive sensor. Hence, it is influenced by its input frequencies. Generally, capacitive sensor has non-contact characteristic. It also needs specific signal conditioning devices. The research on development of capacitive sensor has been done by some researchers. Paczesny, et al, [3] conducted experiment in the capacitive sensor for liquid level measurement made with inkjet printing technology. Furthermore, Wei, et al. [4] conducted a research in implementation and characterization of a Femto-Farad capacitive sensor for pico-liter liquid monitoring. [5] In this project, water level measuring device is designed based on parallel plate capacitive sensor with variation of di-electric. The sensor is made from two resin-insulated aluminum plates and it connected into signal conditioning devices. The change of the water level will change the capacitance value of the sensor which is being represented as the change of voltage on the output which will be feed to the LabVIEW simulator for indication [6]. The LabVIEW will then show the display in on the monitor accordance with the input data from the conditioning circuit [7] [8].

2. Theory

2.1 Working Principle:

Capacitive level instruments operate on the basic principle of the variation of the electrical capacity or capacitance of the capacitor formed by the sensor, vessel wall and dielectric material. A capacitor is made up of two conductive plates which are separated from each other by a dielectric. The storage capability of a capacitor is defined by the capacitance C, is directly dependent on the plate areas (A), their distance (l) and the dielectric constant of the material between the plates.

Capacitive sensors are used in liquids that are non-conductive and have a high dielectric constant (ε) and can be used for continuous level monitoring. In this project, we are using water which has a dielectric constant of 80.1 in room temperature. The capacitance of the sensor is measured between the parallel plates separated by a dielectric. In the portion out of water, air serves as dielectric between the parallel plates. In the immersed section, the dielectric is that of water that causes a large capacitive change as the liquid level changes. The capacitance change is directly proportional to the level of water. If we use any liquid other than water, the dielectric constant of that particular liquid must be known.

The dielectric constant of the process material is an important aspect of this level measurement application. It should be noted that temperature, moisture content, humidity and density can change the dielectric constant of the process material. These factors are often taken into account and corrected for in the design of capacitive sensors for level measurement. Material with low dielectric constants is not suitable for capacitive sensor based level measurement application.
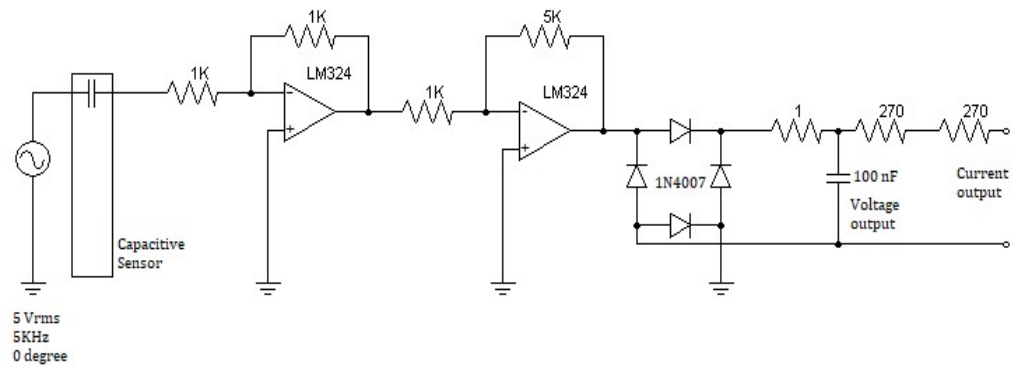
2.2 Circuit Diagram:

Figure 1.1: Circuit diagram of the proposed project

As shown in the Figure 1.1, the circuit diagram consists of a linearization circuit, an inverting amplifier circuit and a rectifier circuit. The function generator is used to supply ac voltage at 5 KHz to the capacitive sensor. The positive end of the function generator is connected to the capacitive sensor and the negative end of the function generator is connected to the ground. A 1KΩ resistor is connected as input resistor between the capacitive sensor and the inverting input terminal of the operational amplifier. The non-inverting input terminal is connected to the ground. A 1KΩ is connected between the output and inverting input terminal as a feedback resistor. Thus, making the amplifier a unity gain amplifier.

Now the output of the operational amplifier is connected to the inverting input terminal of the second amplifier through a 1KΩ resistor and the non-inverting input terminal is grounded. A 5KΩ resistor is connected between the output and inverting input terminal as feedback resistor to make amplifier gain at least 5.

The output of the inverting amplifier circuit is connected to the input terminal of a bridge rectifier and the opposite input terminal is grounded to get DC output. A 1Ω resistor and a 100 nF ceramic capacitor are connected for filtering purpose. To feed proportional current input corresponding to the DC output of the rectified voltage to the AI 9203 analog input card two 270Ω resistors is connected in series.

3. Mathematical Model:

3.1 Sensor Fabrication:

The capacitive sensor is formed from two conductive plates. Both plates have ability to store electrical charges. The value of capacitor C obtains from equation (1); where l is the distance between two plates and ε is dielectric constants of the insulator materials between two plates (which consists of ε_0(permittivity of vacuum) and ε_r (relative permittivity))(equation (2)).

$$C = \frac{\varepsilon A}{l} \tag{1}$$

$$C = \frac{\varepsilon_0 \varepsilon_r A}{l} \tag{2}$$

From equation (1), the capacitance (C) value is affected by the value of ε, A and l. Hence, equation (3) and (4), which shows the influence of the variables to sensor's capacitance value, can be derived from equation (1).

$$\ln(C) = \ln(\varepsilon) + \ln(A) - \ln(l) \tag{3}$$

$$\frac{\Delta C}{C} = \frac{\Delta \varepsilon}{\varepsilon} + \frac{\Delta A}{A} - \frac{\Delta l}{l} \tag{4}$$

$$S = \frac{\Delta C}{\Delta A} = \frac{1}{b}\frac{\Delta C}{\Delta x} = \frac{\varepsilon}{l} \tag{5}$$

Because of the level role as the measuring object, the ideal sensor's sensitivity can be written as equation (5) where l represents the level of liquid and b is width of the sensor. It shows the sensitivity of the sensor depends on water level is a constant if the values of ε and l are also constants. Figure 3.1 shows the fabrication of capacitive sensor.
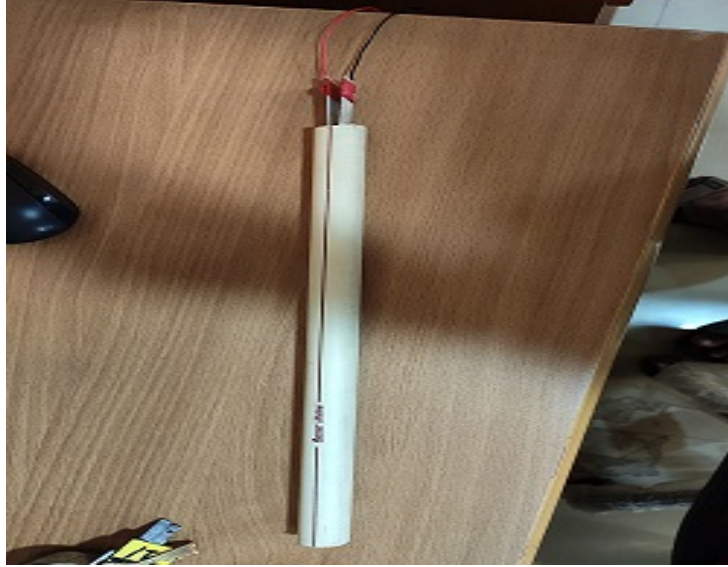
Figure 3.1: Fabrication of Capacitive Sensor

3.2 Implementation with Signal Conditioning Devices:

The sensor is made from two aluminum plates which had dimensions, for every plate, are 0.4m in height (h), 0.011 in width. Both plates separated 0.004 meter from each other and insulated with resin to avoid direct contact with another substances. It helps to give some room for another substance infiltrated between plates and to reduce, or even remove the possibility of electrical short-circuit between two plates when ac input is applied. In the project, capacitive sensor is used to measure liquid level inside a container with 20 cm of maximum depth. The type of liquid used is water ($\varepsilon_r = 80.1$ in 20° C). Figure 3.2 shows the fabrication and installation of the capacitive sensor on the container.

Figure 3.2: Fabrication and Installation of Capacitive Sensor

Capacitive sensor is a passive sensor. Therefore, it needs some signal conditioning device(s) to obtain other quantities (voltage or current) which can be processed on other conditioning and processing devices. In this project, there are three types of signal conditioning circuits: (1) Linearization circuit; (2) Op-Amp inverting amplifier circuit; and (3) rectifier (Figure 2.1). The sensor is located between power source and linearization circuit. Linearization circuit is a circuit which used to obtain linear correlation between its input and output signal. As the ac input is applied, the output equation can be expressed as given in equation (6) where f is the input frequency, R_l is the value of resistor in the circuit, V_{il} represent ac input signal, and V_{ol} is the output of linearization circuit. Assuming the values of V_{il}, R_l, and f are constant, the value of V_{ol} is proportional to capacitance, C.

$$V_{ol} = 2\pi f C R_l V_{il} \tag{6}$$

Other signal conditioning devices which are used in this project are operational amplifier and rectifier. Operational amplifier is operated on the inverting mode since it has linear amplification characteristics (equation (7)) where R_{fa} is the value of feedback resistor, R_{ia} is the value of feedback resistor, and V_{oa} represents the output

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voltage value of the amplifier. The rectifier circuit is used to convert ac signal into dc to approach compatibility with data acquisition or processing device.

$$\frac{V_{oa}}{V_{ol}} = -\frac{R_{fa}}{R_{ia}} \tag{7}$$

3.3 Calculation of Capacitance Value of Sensor:

The sensor capacitance has non-zero initial value. This result caused by the non-ideal condition of the project. Some part of the sensor which is not submerged into water also had contribution on the capacitance value. It also creates the non-linear characteristic of capacitance value in real condition. This condition can be expressed, if the sensor impurities are ignored, as equation (9).

$$C(x) = \frac{\varepsilon_0 b}{l}(\varepsilon_{water}x + \varepsilon_{air}(h - x)) \tag{8}$$

Now, if we put the respective values of $\varepsilon_o(= 8.854*10^{-12}), \varepsilon_{water}(= 80.1), \varepsilon_{air}(= 1), b(= 0.011m), l(= 0.004m)$ and h in the equation (8), we will get the equation (9).

$$C(x) = 1.926x + 0.0097 \tag{9}$$

The relation between level (in meter) and capacitance value (in nF) is shown by equation (9). The correlation between capacitance value and water level is proportional. The regression correlation equation satisfies equation (9) where x represents water level, and $C(x)$ is the capacitance value of the sensor regarding the water level.

3.4 Signal Conditioning Output:

After getting the value of $C(x)$ from equation (9), if we put the value in equation (6), we get the value of the output voltage (V_{ol}) of linearization circuit.

$$V_{ol}(x) = 0.3025x + 0.0015 \tag{10}$$

We get the value of the output voltage (V_{oa}) of the amplifier circuit by putting the value of $C(x)$ from equation (9) in equation (7).

$$V_{oa}(x) = 1.5125x + 0.0075 \tag{11}$$

As shown in figure 1, amplification value of the inverting op-amp circuit is -5 times. However, the average gain value after the signal passes the rectifier circuit is only 27.639 times.

$$V_{dc}(x) = 8.36x + 0.041 \tag{12}$$

where $V_{dc}(x)$ is the output voltage of the rectifier circuit. This output will be feed to the LabVIEW data acquisition input card.

4. Hardware Model:

4.1 Capacitive Sensor:

In this project work we have used parallel plate capacitive sensor. The sensor is made by using two Aluminum plates. The plates are coated with resin to reduce the probability of short circuit. The length and breadth of the Aluminum plates are 40 cm and 1.1 cm respectively. The distance between the two plates is 4 mm. The Aluminum plates are fitted in a ¾" PVC pipe using glue.

The capacitive sensor is then fitted upon the container (bucket) through which the capacitance is measured. Figure 4.1 shows the hardware model of the project.

Figure 4.1: Complete Hardware model of the project

4.2 Conditioning Circuit:

The conditioning circuit of the project work can be divided in three parts: (i) Linearization Circuit, (ii) Inverting Amplifier Circuit and (iii) Rectifier Circuit. The linearization circuit consists of Op-Amps, resistors and the capacitive sensor. The next part is the Inverting amplifier circuit. In this project we used LM324 Quad operational Op-Amps in linearization circuit and inverting amplifier circuit. We have used 1N4007 diode in the full-wave bridge rectifier. Figure 4.2 shows the conditioning circuit.
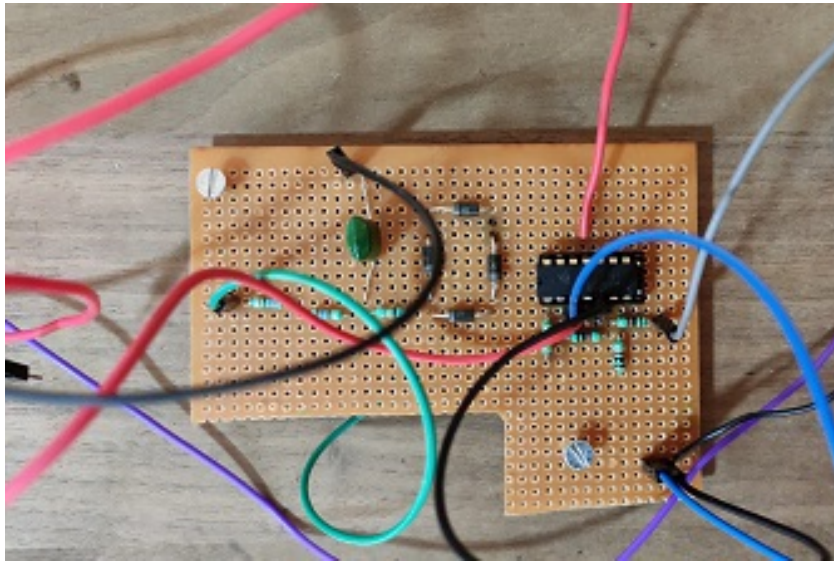

Figure 4.2: Circuit of the signal conditioning Circuit

The Op-Amp in both cases is operating in Inverting mode. The positive inputs (pin 3, pin 5) are connected to the ground. Now in the linearization circuit a resistance of 1KΩ is connected as negative feedback of the Op-Amp between the output (pin 7) and negative input terminal (pin 6) of the Op-Amp. The output of the linearization circuit is connected through a 1KΩ resistance to the inverting mode Op-Amp.

In the inverting mode operational amplifier circuit, there is an 180KΩ resistance is connected as negative feedback between the output (pin 1) and negative input terminal (pin 2). Figure 4.3 and Figure 4.4 shows the linearization and inverting amplifier circuit.
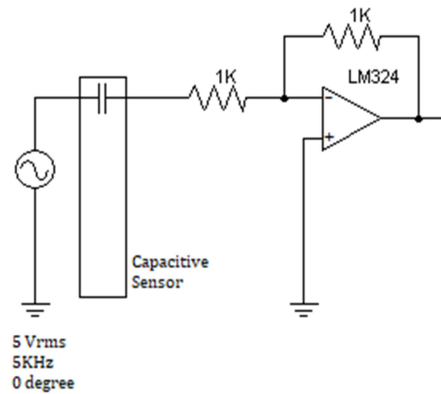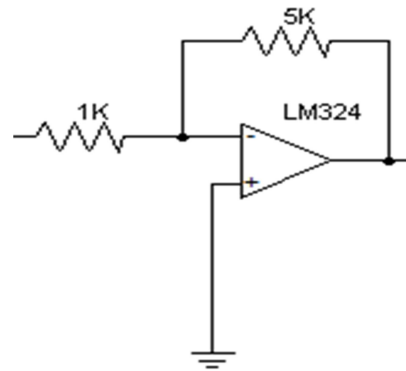
Figure 4.3: Linearization Circuit   Figure 4.4: Inverting Amplifier Circuit

The output of the inverting amplifier circuit is connected to the full-wave bridge rectifier. The output of the full wave bridge rectifier is connected through a 1Ω resistance. A 100 nF ceramic capacitor is connected across the output terminal of the full-wave bridge rectifier to reduce the noise. Furthermore two270Ω resistance is connected in series with the output to get the current output for data acquisition in the LabVIEW software. Figure 4.5 shows the rectifier circuit and filter circuit.
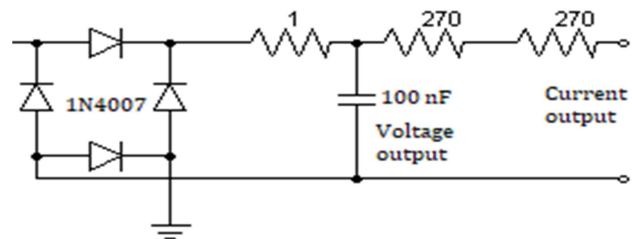
Figure 4.5: The Rectifier and filter Circuit

4.3 Voltage Supply:

In this project, we used the quad operational LM324 amplifiers in the conditioning circuits. The LM324 Op-Amp can operate at supply voltages as low as 3.0V and as high as 32V. In this project, the supply given to the Op-Amps is of 12V.

In the circuit a dual mode voltage supply is fabricated to give the supply voltage to the amplifiers. The voltage supply circuit consists of a center tap transformer (230V AC/12-0-12 V), four 1N4007 diode (full-wave bridge rectifier), and two electrolytic

capacitor, LM7812 as positive voltage regulator and LM7912 as negative voltage regulator. The circuit diagram for the voltage supply is shown in Figure 4.6.

Figure 4.6: Circuit Diagram for the Voltage supply

In the circuit diagram, the main supply of 230 V is connected to the input of the Center tap transformer. The output of the transformer is connected to the input of the full wave rectifier to convert the ac signal to dc. Two capacitors are connected in series across the output of the rectifier circuit.
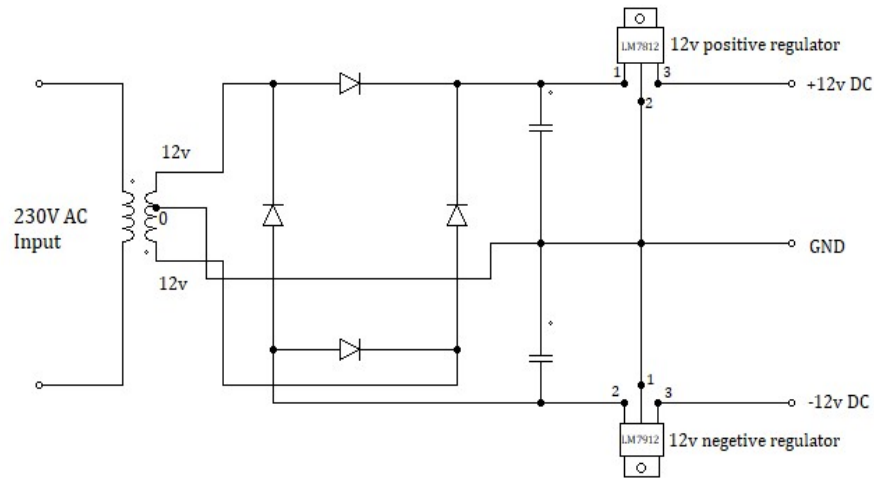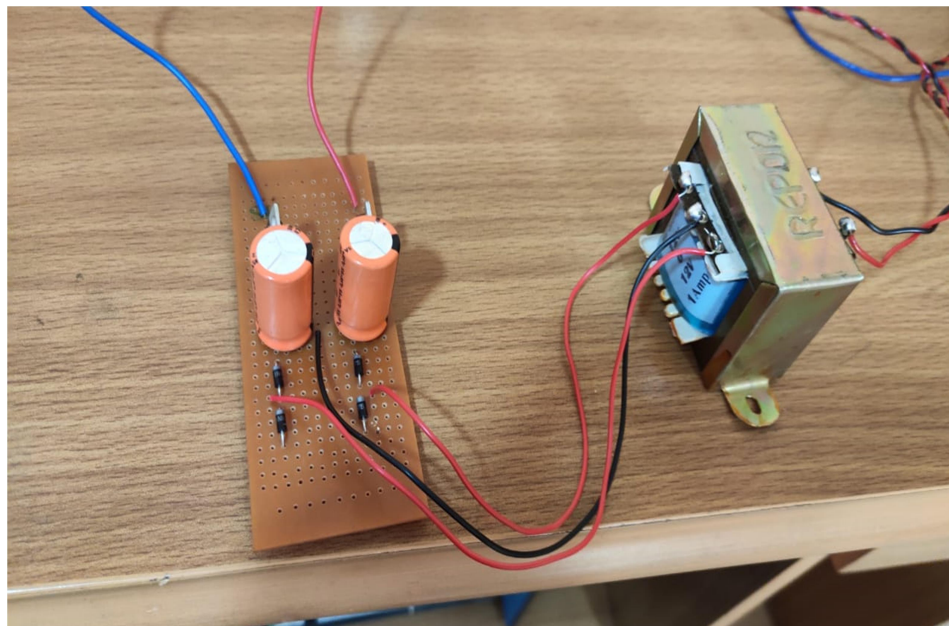

Figure 4.7: Power Supply unit

Now as show in Figure 4.6, the positive leg of the upper capacitor is connected to input (pin 1) of the LM7812 (positive voltage regulator) and the negative leg of the lower capacitor is connected to input (pin 2) of the LM7912 (negative voltage regulator). The ground of LM7812 (pin 2) and LM7912 (pin 1) are short circuited. The ground of the center tap transformer is short circuited with the negative leg of the upper capacitor and positive leg of lower capacitor and the ground of LM7812 and LM 7912. Figure 4.7 shows the supply voltage circuit.

4.4 Function Generator:

A function generator is usually a piece of electronic test equipment or software used to generate different types of electrical waveforms over a wide range of frequencies. Some of the most common waveforms generated by the function generator are the sine wave, square wave and triangular wave. In this project we have used sine wav of 5 KHz frequency and the supply is of 5 V_{p-p}. The output of the circuit is square wave as the conditioning circuit is R-C circuit which acts as an integrator circuit and integrates the sine wave to square wave. Figure 4.8 shows a function generator.

Figure 4.8: Function Generator

5. Implementation of LabVIEW:

5.1 Overview of LabVIEW:

LabVIEW (Laboratory Virtual Instrument Engineering Workbench), created by National Instruments is a graphical programming language that uses icons instead of lines of text to create applications. LabVIEW programs are called Virtual Instruments or Vis for short. It is used for Data acquisition, signal processing (analysis) and hardware control. Figure 5.1 shows a schematic diagram of an instrument based on LabVIEW.
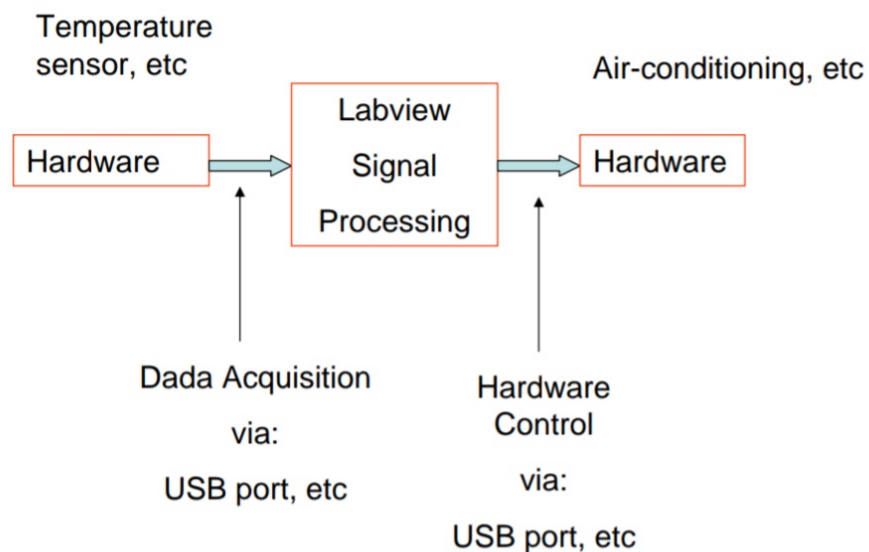
Figure 5.1: Schematic Diagram of an Instrument based on LabVIEW

LabVIEW is consisted of Front Panel Window and Block Diagram Window. Front panel consists of controls and indicators (that is, input and output/display respectively). The Block diagram window consists of terminals corresponding to front panel controls and indicators, as well as constants, function, SubVIs, structure, and wires that connect data from one object to another. Figure 5.2 and Figure 5.3 shows the front panel window and block diagram window respectively.
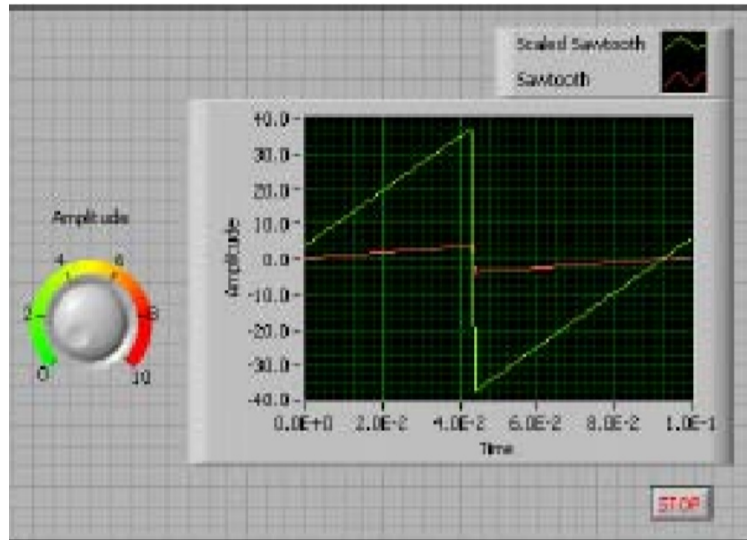
Figure 5.2: Front Panel of a LabVIEW Project
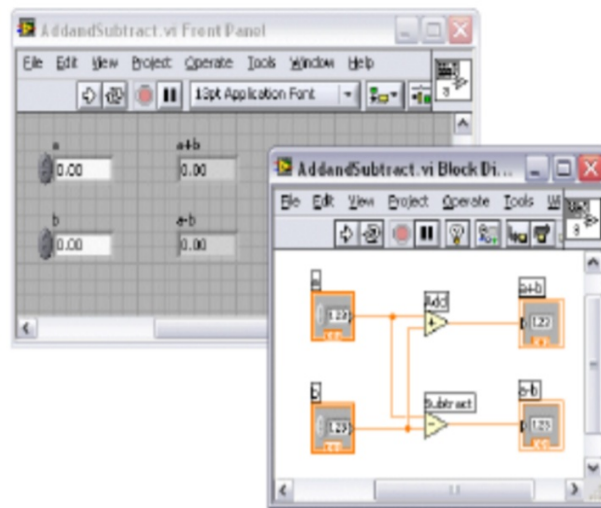
Figure 5.3: Block Diagram Window of a LabVIEW Project

5.2 Configuration of New Project and VI Diagram:

In this project the output of the hardware model is connected to the NI 9203 of the LabVIEW. Now, for data acquisition and signal processing of the output we have created and configured a new project.

Now to work with LabVIEW, We switched off the windows firewall first then also switched off the WIFI. We have deleted all the IP addresses existing in the computer and set up IP addresses. In this case the IP address of LabVIEW is 192.168.10.2 and the subnet mask is 255.255.255.0. We have created a remote system which is now running.

```
┌─────────────────────────────────────────────────────────────────────┐
│  ┌──────────────┐    ┌──────────────┐    ┌──────────────┐            │
│  │ Start LabVIEW│───▶│Create Project│───▶│ Blank Project│            │
│  └──────────────┘    └──────────────┘    └──────────────┘            │
│                                                     │                  │
│                                                     ▼                  │
│  ┌──────────────────┐   ┌────────────┐   ┌──────────────┐            │
│  │New Target & Devices│◀─│ Right Click│◀──│Change Project│            │
│  └──────────────────┘   └────────────┘   │    Name      │            │
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│  ┌──────────────────┐   ┌────────────┐   ┌──────────────┐            │
│  │Real-time Compact  │──▶│ Click on "+"│──▶│Detecting     │            │
│  │       RIO         │   └────────────┘   │  Devices     │            │
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│                                                                        │
│  ┌──────────────┐   ┌──────────────┐   ┌──────────────┐              │
│  │Select Chassis│◀──│Click on Continue│  │Double click on│             │
│  └──────────────┘   └──────────────┘   │    CRIO       │             │
│                                         │  • Scan Mode  │             │
│  ┌──────────────────┐  ┌─────────────┐ │  • FPGA Mode  │             │
│  │Drag and drop A1,  │  │Select FPGA  │ └──────────────┘              │
│  │A0, D1, and D0 to  │  │   mode      │                               │
│  │the Block Diagram  │  └─────────────┘                               │
│  │Panel of new VI    │                                                 │
│  │      file         │                                                 │
│  └──────────────────┘                                                  │
│  ┌──────────────┐   ┌──────────────┐   ┌──────────────┐              │
│  │Go to File Menu│──▶│Open new VI file│─▶│Automatically │             │
│  └──────────────┘   └──────────────┘   │Creates two    │             │
│                     ┌──────────────┐   │  pages        │             │
│                     │Front Panel   │◀──│              │              │
│                     │  Window      │   └──────────────┘              │
│                     └──────────────┘                                  │
│                     ┌──────────────┐                                  │
│                     │Block Diagram │◀──                               │
│                     │  Window      │                                  │
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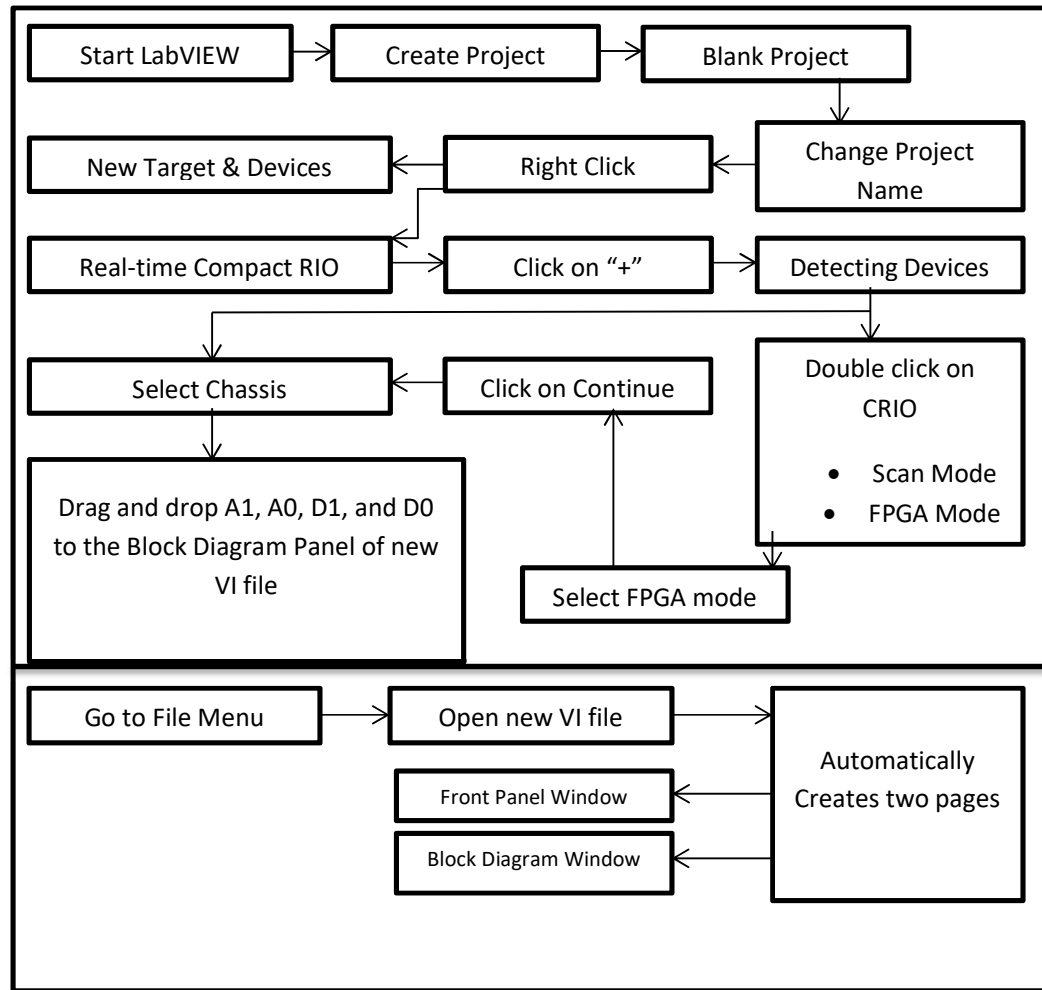
Figure 5.4: Step by step process to make new project in LabVIEW

After the remote network is set up, we have opened LabVIEW. After the LabVIEW terminal is opened we clicked on "Create Project" under which we clicked "Blank Project". We have changed the untitled project name to "Capacitive level measurement". The project file is an ".lvproj" extension. We right clicked on the project name and then we have clicked on "Real-time Compact RIO" on the next panel. We have clicked on the "+" sign to get the action "Detecting devices". We

have doubled clicked on the CRIO and select FPGA mode. As the remote network is established between the LabVIEW modules and the programs, now we have to select the chassis to work with. Now to create new VI file under the new project we have gone to the file menu and then opened a new VI file. Two pages have been created automatically. One is Front panel and the other is Block diagram. Now we drag and drop A1, A0, D1, and D0 to the block diagram panel of the new file. Figure 5.4 shows the step by step process to create a new project in LabVIEW.

5.3 Implemented VI Diagram for Level Measurement:

In the LabVIEW software after opening a new VI file, we dropped the AI0 port and a multiplier. Then we connected a Numeric table and a Tank module to the block diagram and connected it to a waveform chart. We have included a stop button from the while structure and also a time delay to the block diagram. Figure 5.5 shows the block diagram panel of the project. The front panel window is shown in Figure 5.6.
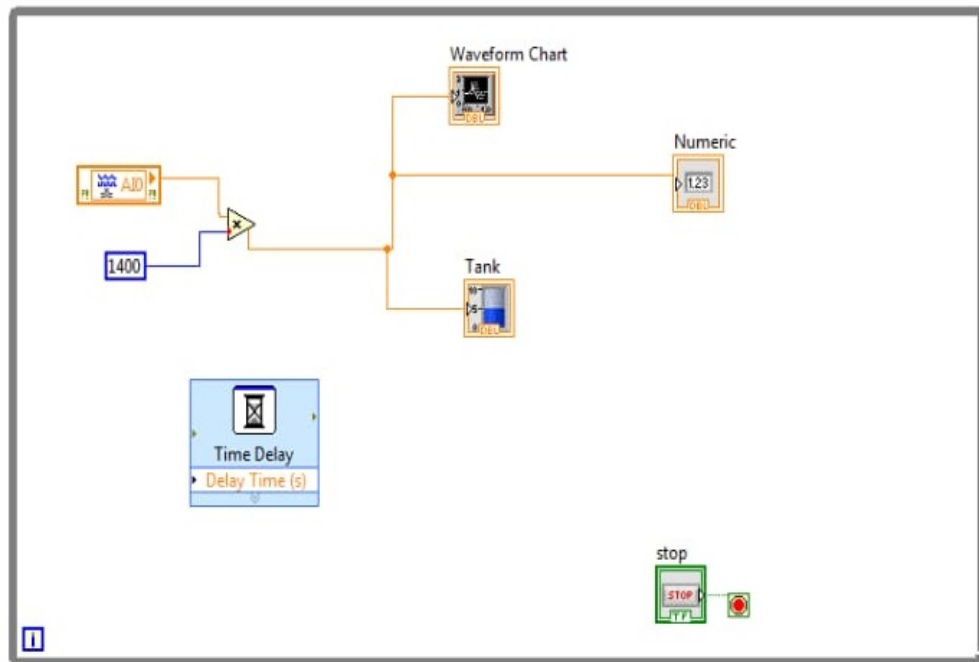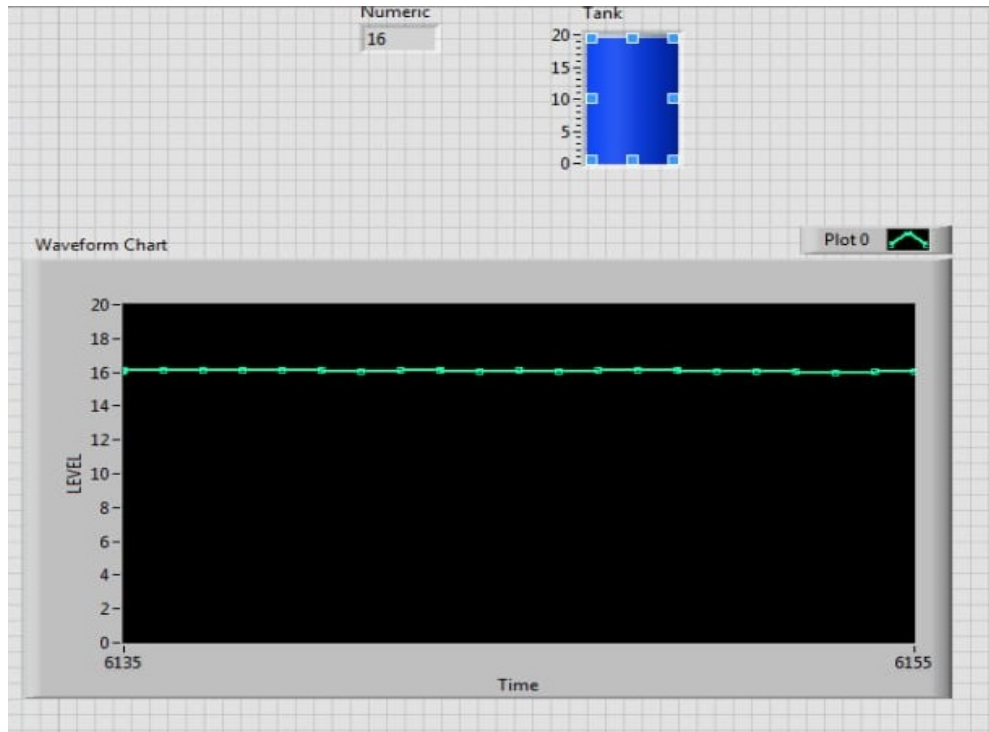

Figure 5.5: Block Diagram Panel of the Project

Figure 5.6: Front Panel Window of the Project

6. Observations and Results:

6.1 Level Measurement Data:

The capacitance of the capacitive sensor has a proportional relation with the level of the container. A table (Table 6.1) is given below to show the data.

The capacitance has the unit of nF and the height is in meter.

Table 6.1: Capacitance value with respect to water level

Serial No.	Height (meter)	Capacitance (nF)
1	0	0.0097
2	0.02	0.0482
3	0.04	0.0867
4	0.06	0.1253
5	0.08	0.1638
6	0.1	0.2023
7	0.12	0.2408
8	0.14	0.2793
9	0.16	0.3179
10	0.18	0.3564
11	0.20	0.3949

The output voltage of the linearization circuit with respect to water level is also shown in Table 6.2.

Table 6.2: Output voltage of linearization circuit with respect to water level

Serial No.	Height (meter)	Output Voltage (V)[AC]
1	0	0.0015
2	0.02	0.0075
3	0.04	0.0136
4	0.06	0.0196
5	0.08	0.0257
6	0.1	0.0317
7	0.12	0.0378
8	0.14	0.0438
9	0.16	0.0499
10	0.18	0.0559
11	0.2	0.0621

Now the output voltage of the rectifier circuit with respect to the water level is shown in Table 6.3.

Table 6.3: Rectifier output voltage with respect to the water level

Serial No.	Height (meter)	Output Voltage (V) [DC]
1	0	0.041
2	0.02	0.2082
3	0.04	0.3754
4	0.06	0.5426
5	0.08	0.7098
6	0.1	0.8770
7	0.12	1.0442
8	0.14	1.2114
9	0.16	1.3786
10	0.18	1.5458
11	0.2	1.7130

6.2 Calibration Graph:

After calibrating the capacitance value with respect to the water level from Table 6.1 we can determine the calibration graph in Figure 6.1. The capacitance is plotted in y axis and the water level is plotted in x axis.
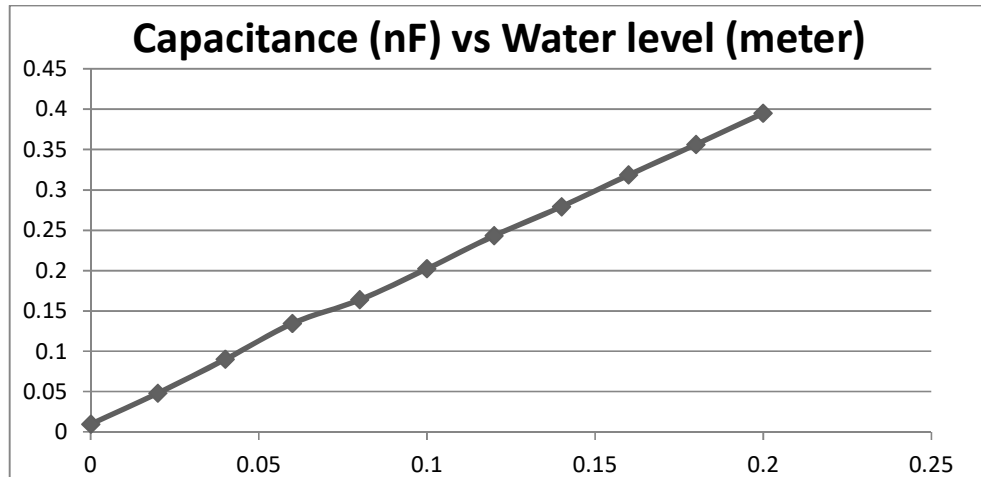
Figure 6.1: Graph of Capacitance value with respect to water level

The output of linearization circuit and the rectifier circuit is also plotted on the graphs in Figure 6.2and Figure 6.3 respectively where the voltage is in y axis and the water level is plotted in x axis. In case of the linearization circuit the output voltage is AC and in case of the rectifier, the output voltage is DC.
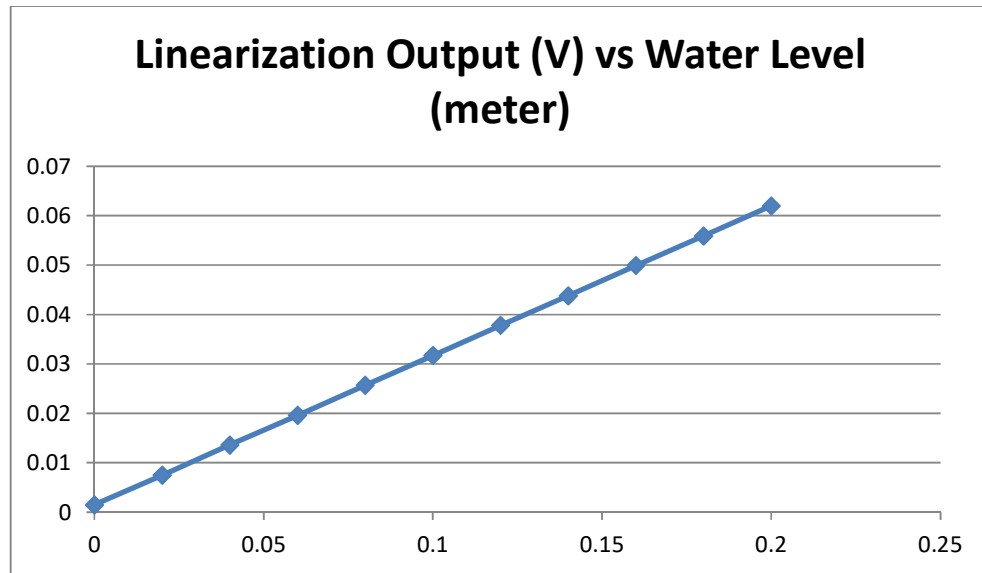

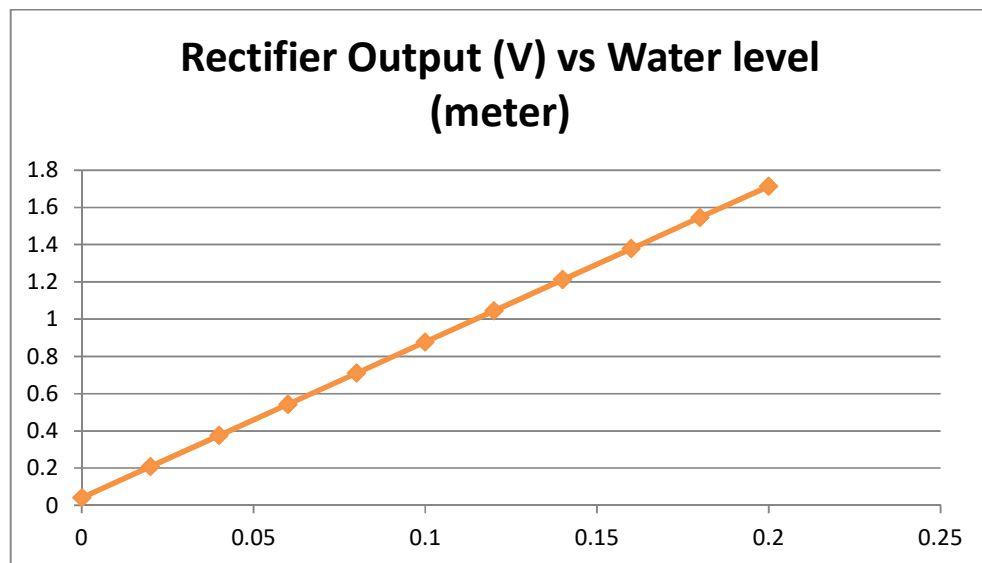Figure 6.2: Graph of Linearization Output Voltage with respect to Water level

Figure 6.3: Graph of Rectifier Output with respect to Water level

6.3 LabVIEW Based Measurement and Display:

In this project, the output of the conditioning circuit is connected to the LabVIEW terminal for data acquisition with respect to the change in output characteristics due to change in the water level as the change in water level changes the capacitance of the capacitive sensor. Figure 6.4 to Figure 6.9 shows the LabVIEW display of water level.
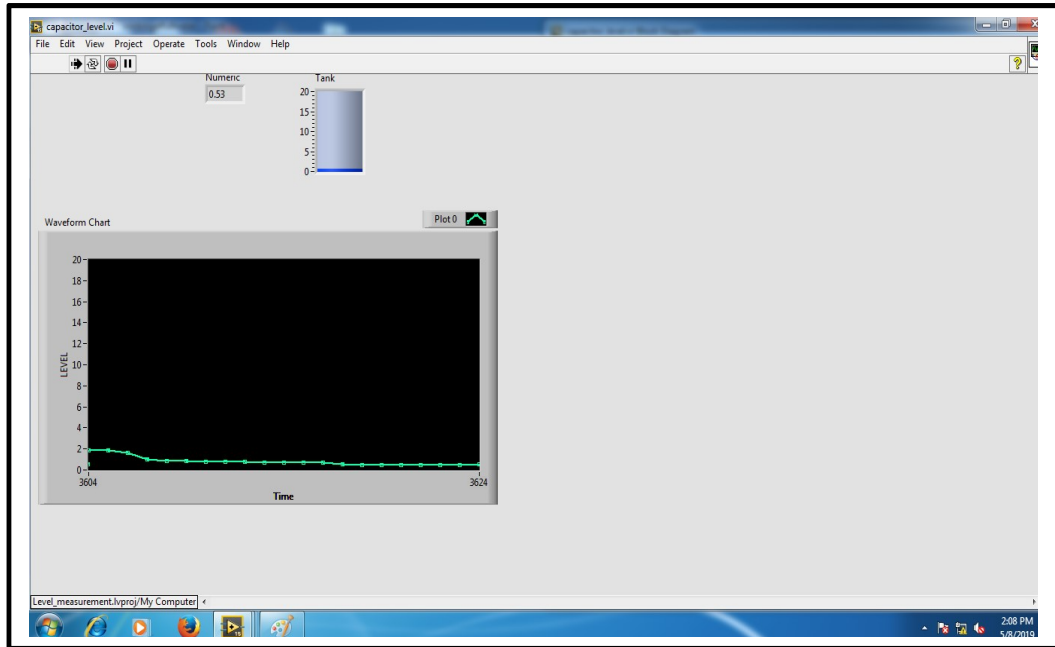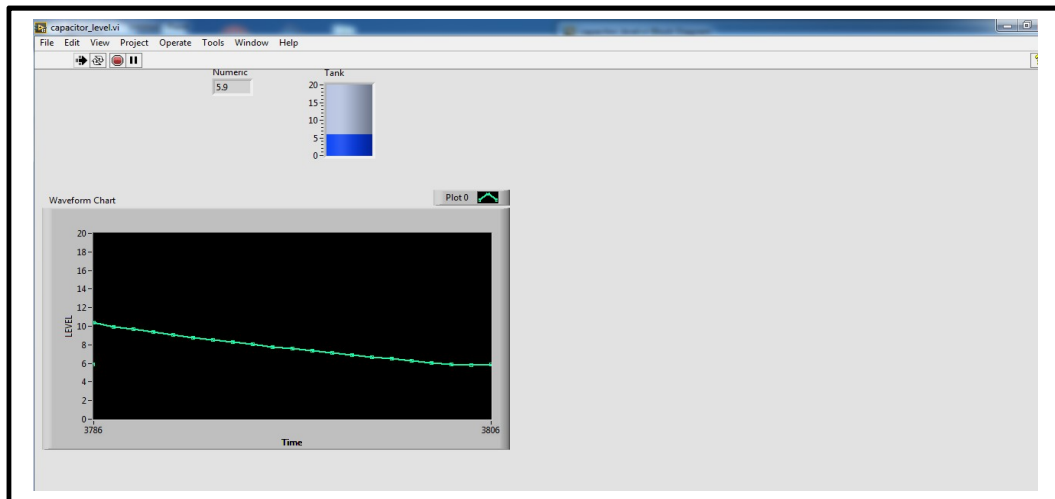

Figure 6.4: LabVIEW Display at Fully Empty Condition

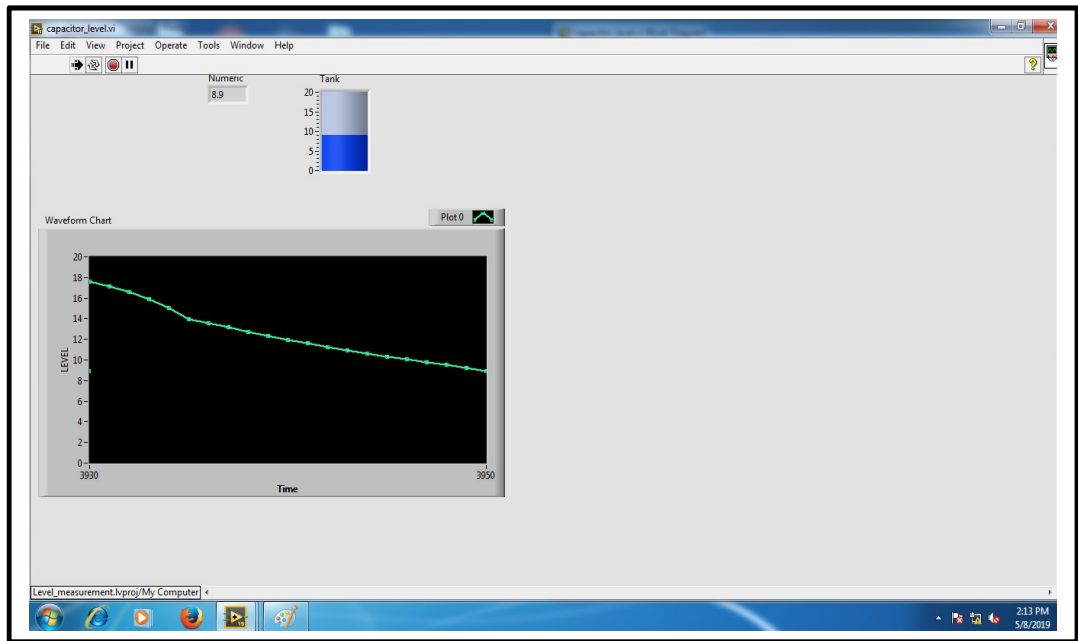Figure 6.5: LabVIEW Display when the Water Level is at 4 cm.

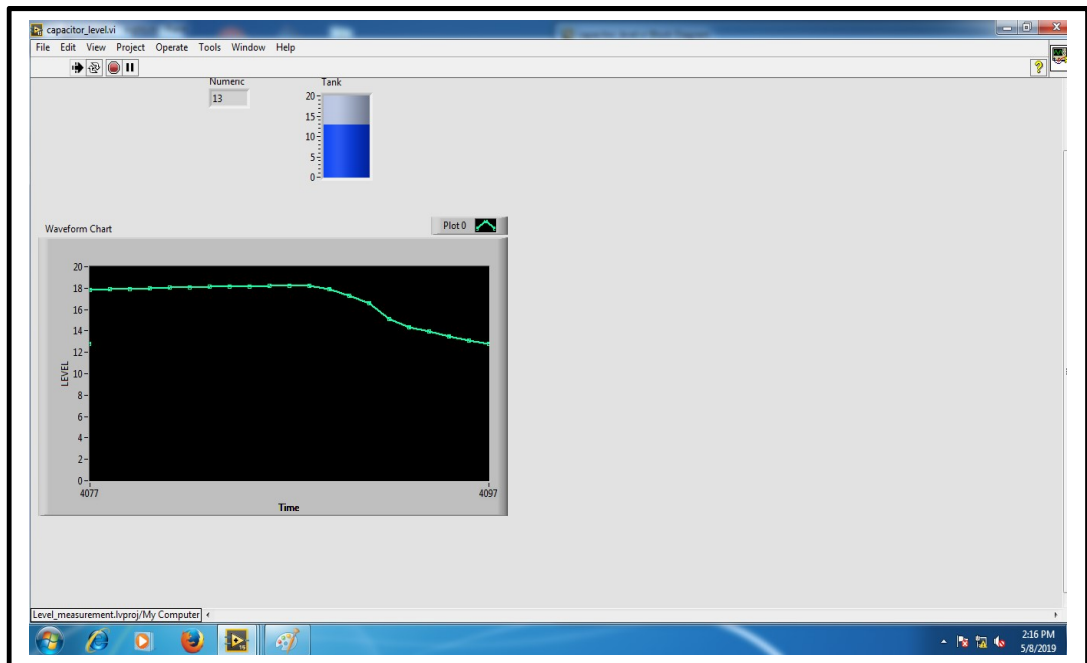Figure 6.6: LabVIEW Display when Water Level is at 8 cm.

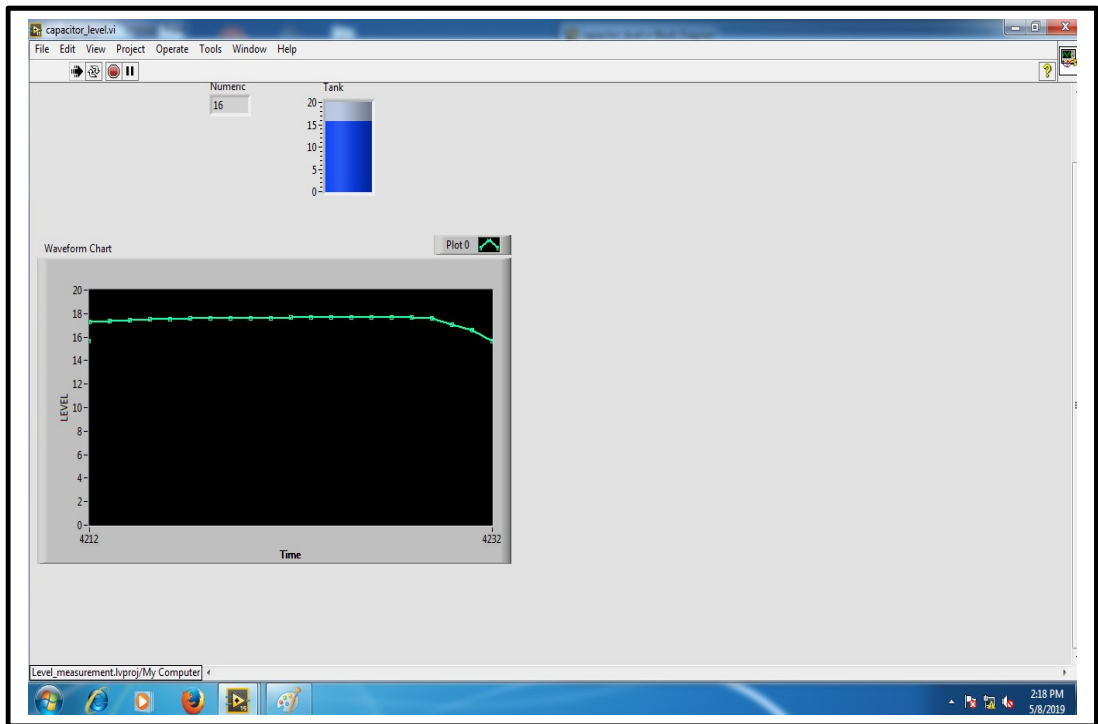Figure 6.7: LabVIEW Display when the Water Level is at 12 cm

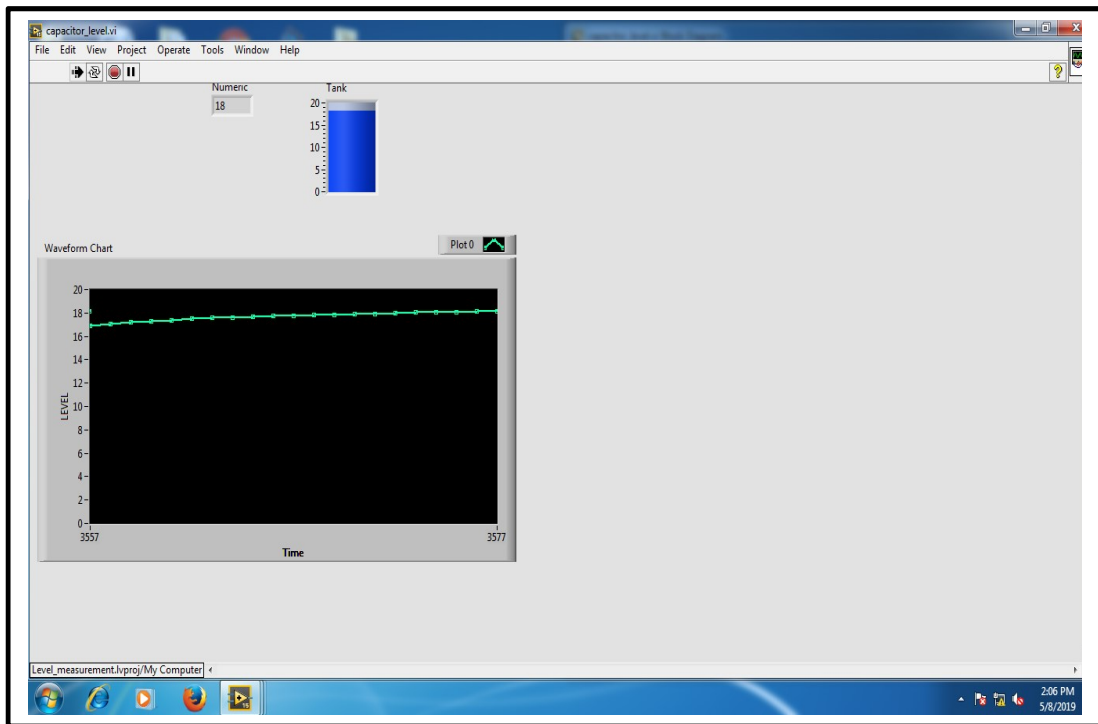Figure 6.8: LabVIEW Display when the Water Level is at 16 cm.

Figure 6.9: LabVIEW Display when the Water Level is at 20 cm

7. Conclusion:

A capacitive sensor for water level measurement had been developed and tested. It is connected to the 5 V_{p-p} 5KHz ac input voltage and signal conditioning devices to obtain output voltage signal. The output voltage is converted into current signal by connecting two 270Ω resistors. Depending on the water level the capacitance of the sensor is proportionally changing. The range of the capacitance value is between 0.0097 (at 0 cm) nF and 0.3949 (at 20 cm) nF and can be approximated by the equation $C(x) = 1.926x + 0.0097$. Furthermore, the correlation between water level and dc output voltage can be expressed as $V_{dc}(x) = 8.36x + 0.041$.

The results of the experiments also inform the effect of non-ideal condition. Now the output from the conditional circuit is connected to the NI 9203 card of LabVIEW software. The display is shown in the monitor through data acquisition from the conditioning circuit by the NI 9203 card. As the capacitive sensor is very sensitive to its surroundings, the non-ideal conditions such as impurities in water, temperature, dielectric constant, humidity, et cetera causes some minute variation in display.

This project can be used in measurement of any liquid. This project can be further developed for controlling the liquid level in a larger container. In case of industry this project can be modified to remotely manage the production and liquid level. Using modern technology such as machine learning, artificial intelligence this prototype project can be made more efficient for use in the industries.

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