Research Article
ISSN:2249-1236
CODEN: IJRRBI
Nasser M. Al-Dwaik, A ***et al., Int.*** **J. Res. Rev. Pharm. Appl. Sci.,*(2023) 12(1) 024-037***

International Journal of Research and Reviews in Pharmacy and Applied sciences

Capacitive Transducer

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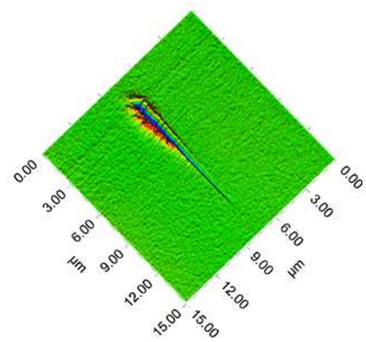
Article received: 29.11.2023
Article Accepted: 23.12.2023



Abstract:

In this Paper, we have applied the electrical circuit known as the Wheatstone Bridge capacitor to know the percentage of salt and impurities in some liquids.

Many sensors have a primary sensing element that converts the variable inputs to a resistance, such as strain gauge and thermistor. Therefore, such sensors need a variable conversion element that converts the change in resistance to an electric voltage change. Wheatstone Bridge is used for this purpose.

Keywords: Capacitive Transducer, Capacitance Wheatstone Bridge, Capacitor Permittivity and Dielectric Constant

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Introduction:

Transducer Capacitive:[1]

The definition of the capacitive transducer is to measure the displacement (how much distance it covers), pressure and other several physical quantities, these transducers are preferred. In these transducers, the capacitance between the plates is varied because of the distance between the plates, overlapping of plates, due to dielectric medium change, etc.

The working principle of a capacitive transducer is variable capacitance. As per its structure, these have two parallel metal plates which maintain the distance between them. In between them, dielectric medium (such as air) can be filled. So, the distance between these two metal plates and positions of the plates can change the capacitance. So, variable capacitance is the principle of these transducers. The basic difference between the normal capacitors and capacitive transducers is, the capacitor plates are constant in normal capacitors wherein these transducers, capacities are movable condition. Fig.1.

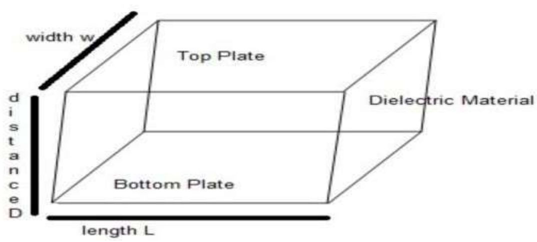

Fig.1: Structure of Capacitive.

The capacitance of the variable capacitor can be measured by this formula.

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

In this Formula:

C: indicates the capacitance of the variable capacitance εo: indicates the permittivity of free space
εr: indicates the relative permittivity A: indicates the area of the plates
D: indicates the distance between the plates

So according to the formula, the variable capacitance value is dependent on four important parameters. They are the distance between the plates of the variable capacitor, occupying area of the plates, permittivity of the free space, relative permittivity, and dielectric material. These parameters can varythe capacitance value of the variable capacitor.

Change in dielectric constant can vary the capacitance of this transducer.
The area of the plates of these transducers can vary its capacitance value.
Distance between the plates can vary the transducers' capacitance value. This method is mostly used. In this method, the dielectric medium and area of the plates are kept constant. When the plates are moving then the distance is varied and this results in the changing of the capacitance of the transducer.

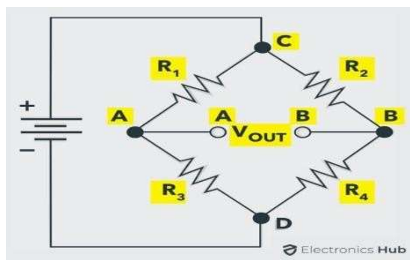

Fig.2: A Wheatstone Bridge Consists of Four Resistors.

This bridge is used to find the unknown resistance very precisely by comparing it with a known value of resistances. In this bridge, a Null or Balanced condition is used to find the unknown resistance.

For this bridge to be in a Balanced Condition, the output voltage at points A and B must be equal to 0.From the above circuit:

The Bridge is in Balanced Condition if:

VOUT = 0 V

If we know the values of three resistors, we can easily calculate the resistance of the fourth resistor.

R1 / R3 = R2 / R4

Relative Permittivity - The Dielectric Constant:[3]

The dielectric constant - also called the relative permittivity indicates how easily a material the can become polarized by imposition of an electric field on an insulator. Relative permittivity is the ratio of"the permittivity of a substance to the permittivity of space or vacuum".

Relative permittivity can be expressed as ($\varepsilon r = \varepsilon / \varepsilon 0$)
Where:

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εr = relative permittivity - or dielectric constant ε = permittivity of substance (C2/ (N m2))

ε0 = permittivity of vacuum or free space (8.854187817 10-12 C2/ (N m2))Relative permittivity - εr- for some substances. as in Table (1).

Note that permittivity may change with temperature for some materials.

Table (1): Relative permittivity - εr- for some substances.

Material	Relative Permittivity - εr -
Water	80.1
Air (Dry) (68° F)	1.000536
Air, Liquid (-191oC)	1.4
Diesel	2.1
Oil	2
Olive Oil	3.1
Benzeen	2.28

Capacitor permittivity and dielectric constant:[4]

Permittivity and dielectric constant are two terms that are central to capacitor technology. Often talk will be heard of capacitors with different dielectrics being used when selections of electronic components are being made within an electronic circuit design.

Electrolytic capacitors, ceramic capacitors,, paper, tantalum capacitors and all the common names forcapacitors refer to the dielectric material that is used. As shown in Fig.3.

The dielectric material provides insulation between the capacitor plates, and in addition to this it determines many of the characteristics of the capacitor.

The dielectric of the capacitor governs the level of capacitance achievable in a certain volume, fig.4, the temperature stability whether it is polarized or not. These and many other characteristics are all a function of the dielectric material used – many properties being governed by the dielectric constant itself.

Fig.3: A Selection of Capacitors with Different Dielectrics.

The terms permittivity and dielectric constant are the same for most purposes, although there are instances where the different terms do have very specific meanings

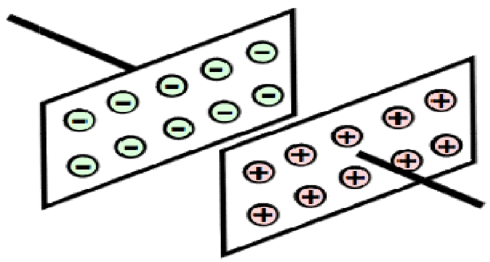

Fig.4: The Dielectric Constant of the Material Between the two Plates Governs the Levels of Capacitance Achievable.

It is that property of a dielectric material that determines how much electrostatic energy can be stored per unit of volume when unit voltage is applied, and as a result, it is of great importance for capacitors and capacitance calculations and the like.

In capacitors, the two plates are kept apart by an insulator - this is the dielectric material that governs many of the properties of the capacitor
Early capacitors tended to be metal plates that were kept apart by the mechanical construction of the whole assembly.

More modern capacitors have an insulating dielectric material placed between the plates. This provides two main advantages:

Separates plates: As capacitors become smaller and need to be more robust, it is necessary to place an insulating material between the plates to ensure they remain apart. With capacitors becoming very small and very close separation between the plates being needed to have the required level of capacitance, it becomes essential to place the insulating dielectric between them. Increases level of capacitance: By selecting the right dielectric, the level of capacitance can be increased considerably when compared to air. and it is possible to achieve very high

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levels of capacitance in a small volume.

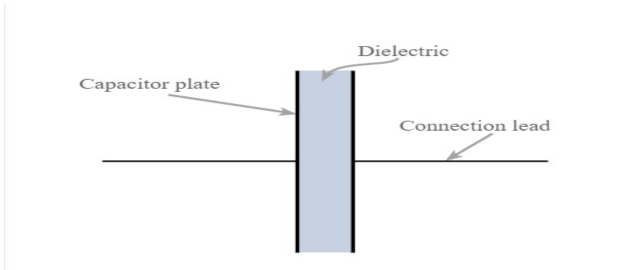

Fig.5: Simplified View of Construction of Capacitor Showing the Plates and Insulating

Dielectric.howg.5,shows how a very basic capacitor is constructed with a dielectric between the plates. As most field the electric field lines field virtually parallel between the two plates, having the dielectric only between the plates is perfect Real missable.

For real they consist of multiple plates between each to enable a level of capacitance to be achieved, each with a layer of dielectric insulating material between them.

Methodology:

Block Diagram of the Paper:

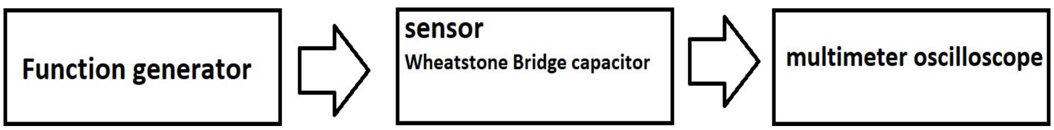

Fig.6: Block Diagram of the Paper.

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Hardware:

-Function generator:

-Wheatstone Bridge capacitor:

The capacitor was made manually for several reasons:

1- We did not find a sensor in the market that fits our Paper.

2- The desire of the work team to apply what has been learned in the subject of sensors in terms of lawsand mathematical equations.

Specifications of Wheatstone Bridge capacitor: V input= 5 Ac v – 5KHz.
C1= Variable Capacitor 10 – 35 PF. C2= 33 PF.
C4= 33 PF.

C3= Capacitor + Transducer 33 PF when εr= 1.

-multimeter oscilloscope

Capacitance for Diesel: Fig.8. εr= 2.1

ε0= 8.85 PF/m

d= 1 CM

A= 3.7 CM^2

Software:

The Multisim program was used to adjust the capacitor and to know the readings that will appear to usduring the experiment.

Capacitance for Water:

Fig.10. εr= 80.1

ε0= 8.85 PF/m

d= 1 CM

A= 3.7 CM^2

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Capacitance for Benzene: Fig.9. $\varepsilon r = 2.28$

$\varepsilon 0 = 8.85$ PF/m

d= 1 CM

A= 3.7
CM^2

$$c = \frac{2.28 \times 8.85 \times 3.7 \times 10^{-2}}{1 \times 10^{-2}} = 74.6\,pF$$

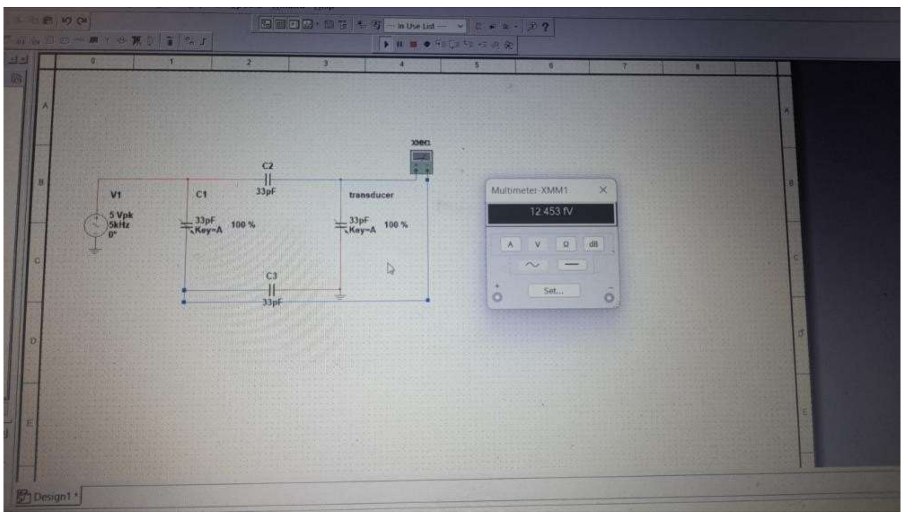

Fig.7: calibration on The Multisim program.

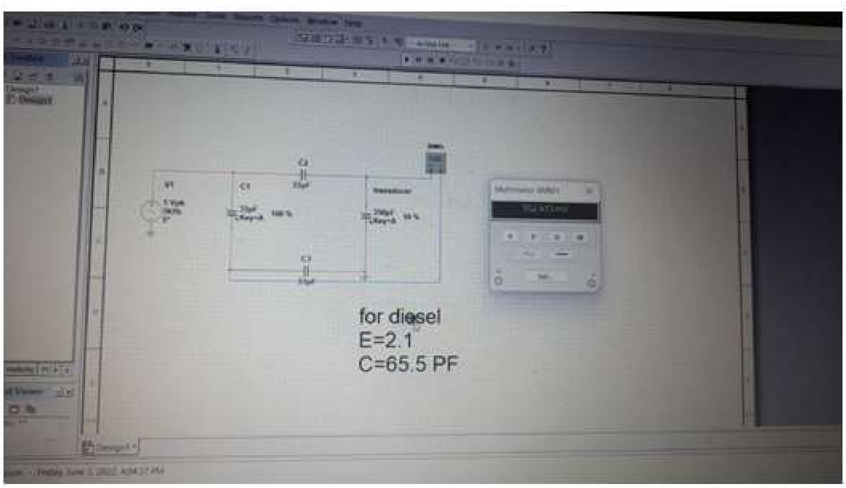

Fig.8: Result of Diesel on The Multisim program.

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$$c = \frac{80.1 \times 8.85 \times 3.7 \times 10^{-2}}{1 \times 10^{-2}} = 2.6\,nF$$

$$c = \frac{2.1 \times 8.85 \times 3.7 \times 10^{-2}}{1 \times 10^{-2}} = 65.5\,pF$$

9

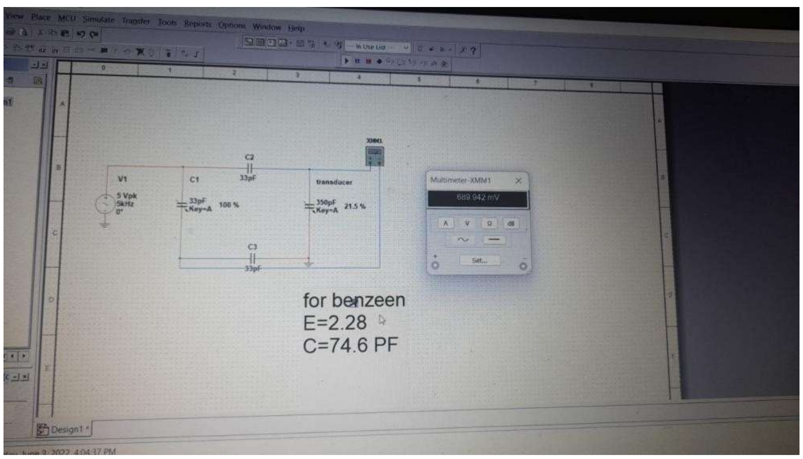

Fig.9: Result of Benzeen on The Multisim Program.

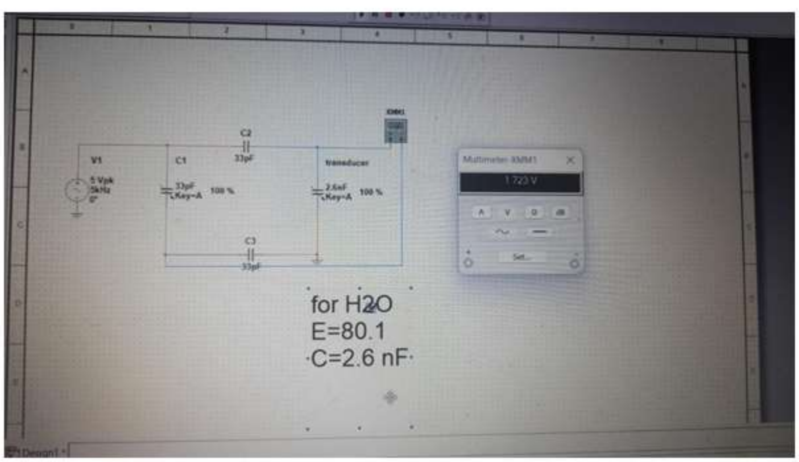

Fig.10: Result of Water on The Multisim Program.

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Results and Discussion:

This experiment was done manually based on the capacitor law. In this experiment, we used constantcapacitor strain gage c= 33PF.

We use the capacitor by **Pico farad** to see the change n the voltage in the experiment without amplifier.The measurements we adopted in our work are as follows:

εr= 1 For Air.

ε0= 8.85 PF/m.

d= 1 CM. (Until the distance is reduced

manually).C= 33 PF. (To be a Result of Strain

gage= 0).

Through these data, we applied the law and deduced the space.

$$c = \frac{\varepsilon r \ \varepsilon 0 \ A}{d}$$

$$33 = \frac{1 \times 8.85 \times A}{1 \times 10^{-2}}$$

A= 3.6
CM^2

Since the shape is square, A= length * width

Fig.11: Test on Water.

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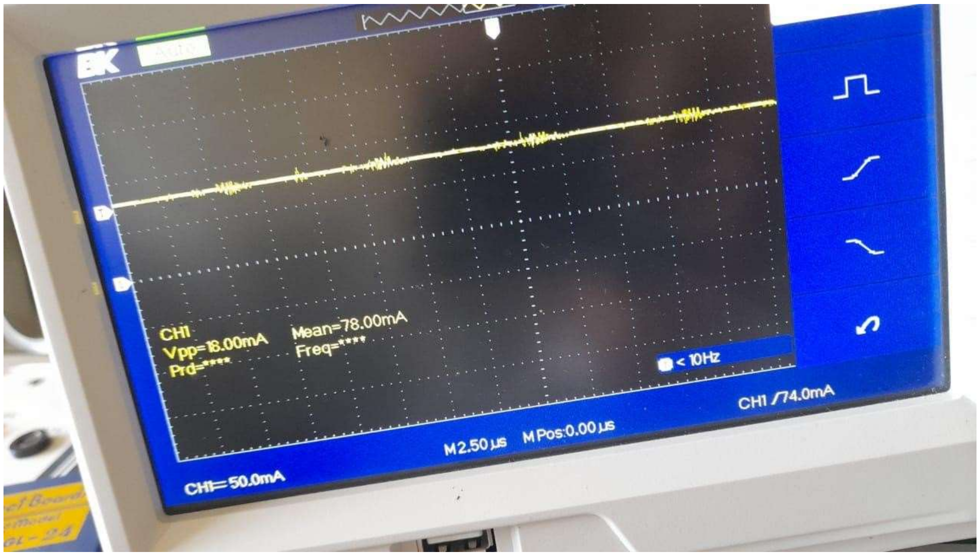

Fig.12: Result of Test on Water.

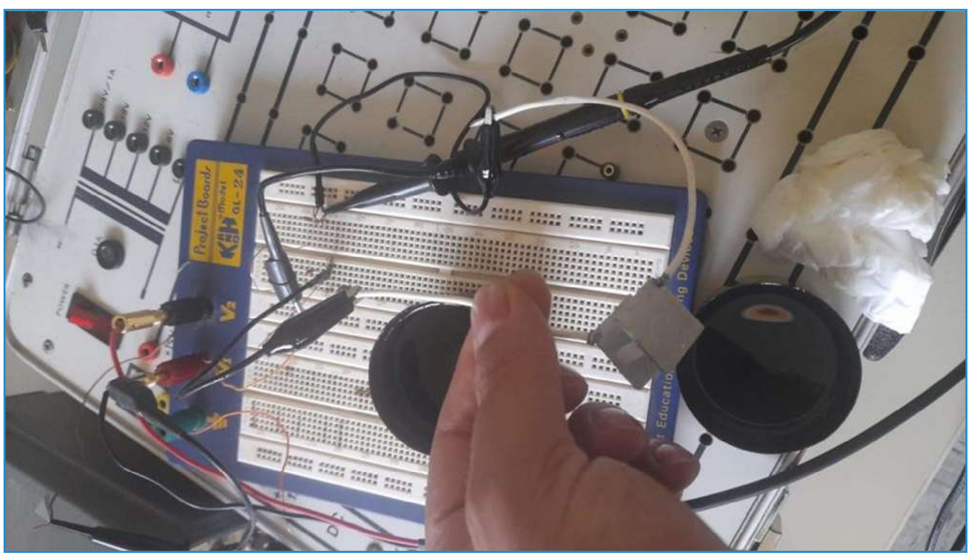

Fig.13: Test on Air.

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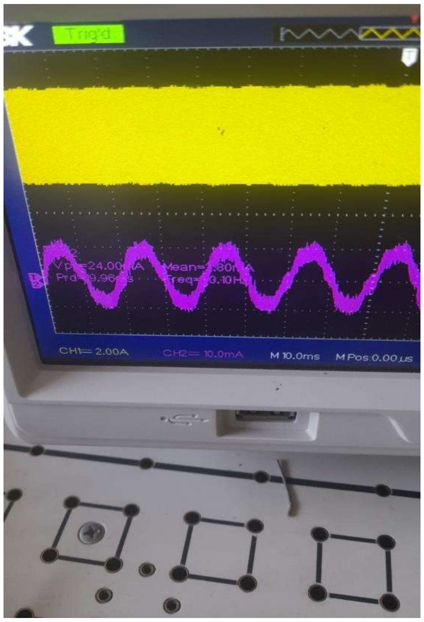

Fig.14: Result of Test on Air.

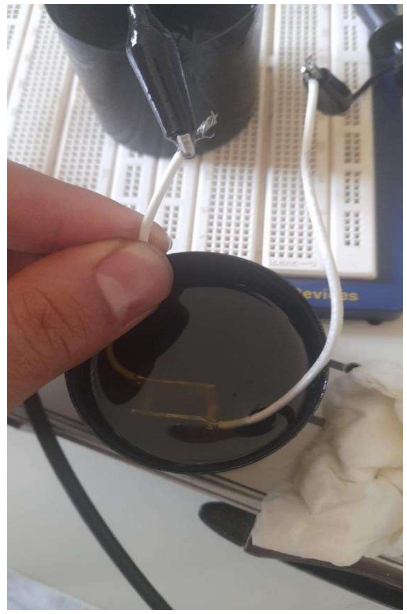

Fig.15: Test on engine Oil.

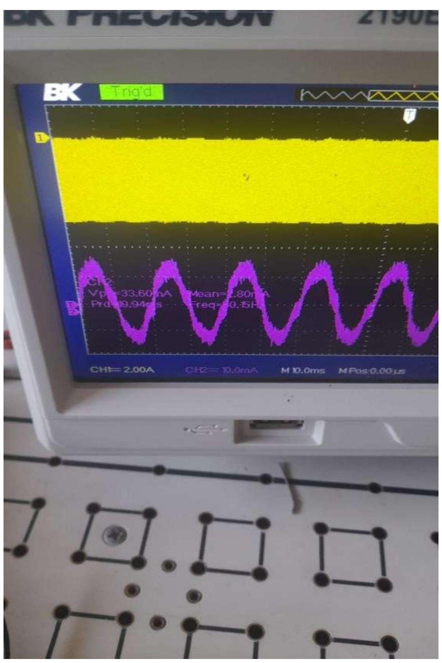

Fig.16: Result of Test on Oil.

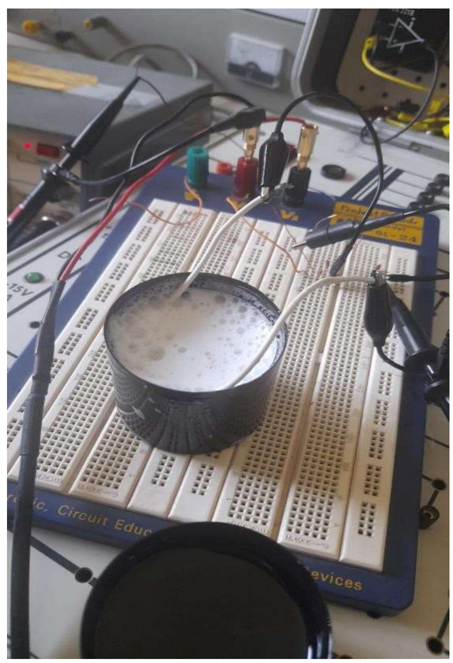

Fig.17: Test on Water with Hand Wash.

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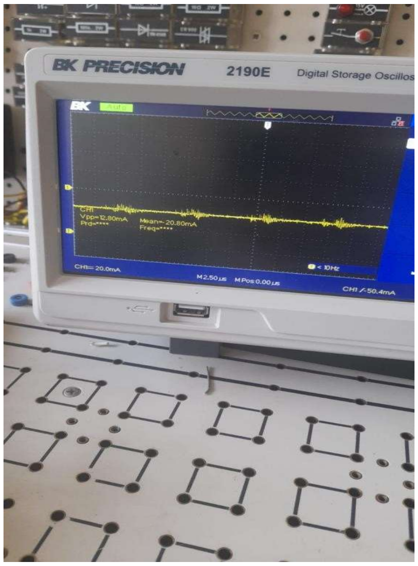

Fig.18: Result of Test on Water with Hand Wash.

Fig.19: Test on Water with Hand Wash with Air.

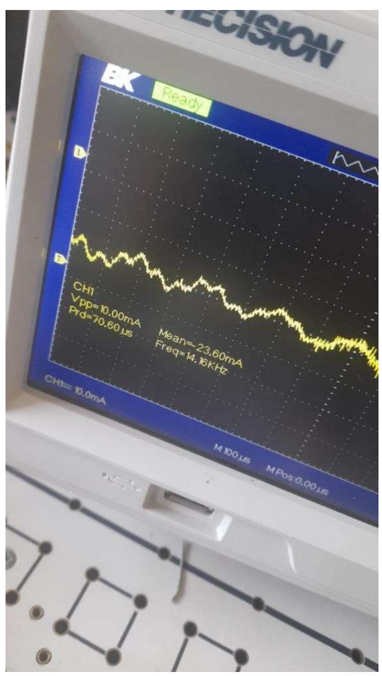

Fig.20: Result of Test on Water with Hand Wash with Air.

Conclusion:

In this little research, we made an electrical circuit that can tell the percentage of impurities in liquids,using a Wheatstone Bridge capacitor, and read the results on a multimeter oscilloscope.

The results shown to us through the experiment were compared with the results of previous researchers, and some of their results have been attached to this Research.

Future Work:

To continue this Research and make a more accurate circuit, these components are shown in FigureNo.21.

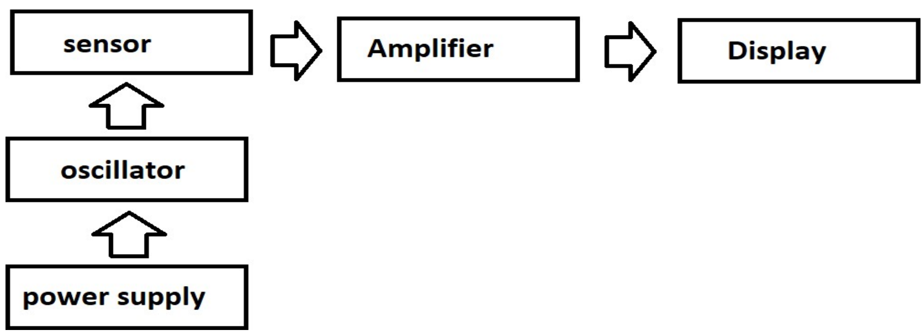

Fig.21: Future Work.

The reasons that prevented the work team from implementing this department are the following: 1- The lack of a variable capacitor in the market gives accurate and incorrect readings

2- The materials are expensive for work team.

3- The desire of the work team to manually configure the department to apply what has been learnedfrom the subject of sensors.

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