Design and Construction of a Formalin Detector using the Conductivity Property

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Abstract— **Now a days, formalin adulteration of food has become a severe problem in Bangladesh. At present there are two ways to detect formalin in our country. One is chemical based test which is difficult for general people to understand how to use it and other is formalin detection device which is very costly. So, we have made a formalin detection kit in a cost effective way which is also easy to use. This formalin detection kit was implemented using electrical conductivity property of formalin. Conductivity of formalin changes with the change of concentration of formalin. This kit shows the absence and presence of formalin in three levels.**

***Keywords*— Formalin, Conductivity, Cost Effective, Operational Amplifiers, Comparator**

I. INTRODUCTION

In recent situation, food (such as fish, fruits, milk etc.) adulteration problem by formalin has become acute in Bangladesh. It has become a big issue at present. Already several initiatives have taken to detect formalin in Bangladesh. Recently, scientists in Bangladesh have invented a new method to detect formalin in fish. In this method, formalin is detected within 30 seconds which is a chemical based test.[1] But the use of this kit is little complicated and many people don't understand how to use this kit. Besides, the formalin detection machines are very costly in Bangladesh, it is about $259,[2] so the general people don't have the ability to buy it, only some machines are used in market to test formalin. So, the goal of this project is to make a formalin detection kit in a cost effective way by using conductivity property so that it is available to general people.

II. WORKING METHOD

A. Block Diagram

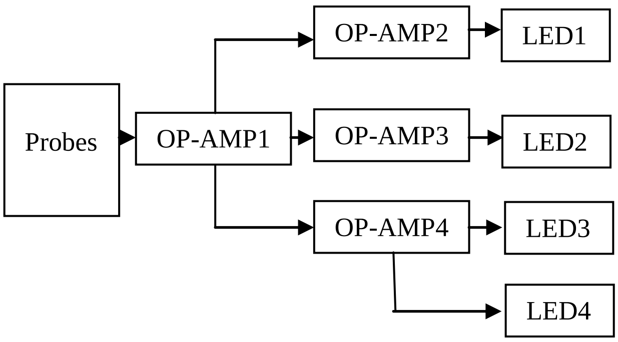

Fig. 1 Block Diagram of formalin detection device

Two probes (space between two probes 0.55cm) are used to measure the resistance of different concentration of formalin. Four operational amplifiers[4] are used shown in Fig.1. Operational amplifier 1 is non-inverting closed loop differential amplifier and operational amplifier 2,3,4 are comparators. Four LEDs are used to show the presence of formalin.

B. Circuit Diagram

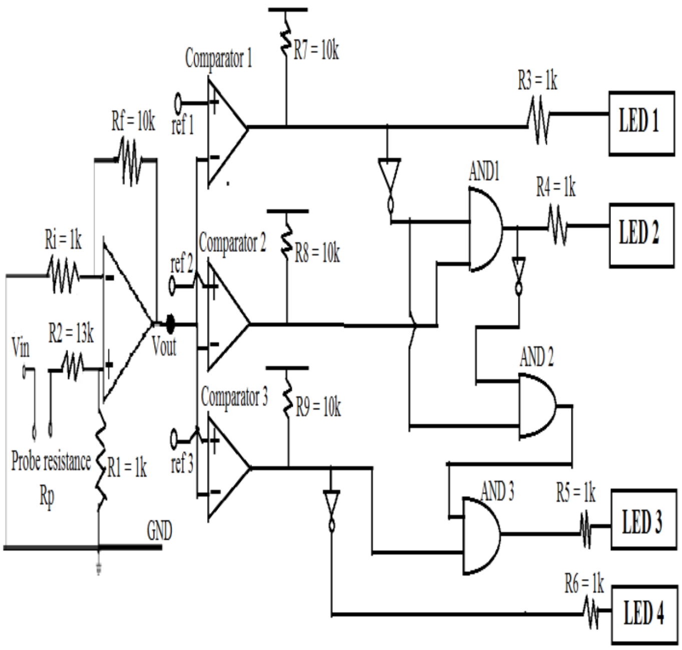

Fig. 2 Experimental Circuit Diagram

To design this formalin detection circuit, conductivity property[3] of formalin is used. The probe is connected to the noninverting(+) terminal of the closed loop amplifier. When the concentration of formalin increases, probe resistance (R_p) decreases as conductivity increases. So, the output of the noninverting closed loop amplifier increases and vice versa. For the three comparators[5][6], three different reference voltages are fixed to the noninverting(+) terminal and their three inverting (-) terminals are connected to the output terminal of the closed loop amplifier. For the pure fish the output voltage of closed loop amplifier is 1.4V, for 5% formalin in fish 1.72V, for 30% formalin in fish 2.15V and for 50% formalin in fish it is 2.48V. So, the reference voltages of the comparators are set according to the output voltage of the closed loop amplifier by using three variable resistors. The reference of the comparator 1 is 1.5V, so the comparator 1 and LED 1 are on when the close loop amplifier's output is in between 0 – 1.49V. To on comparator 2 and LED 2, the reference voltage is set to 1.8V, so the comparator is on when closed loop amplifier's output is in between 0-1.79V. For the comparator 3, the reference voltage is 2.2V, so the comparator 3 and LED 3 are on, when the closed loop amplifier's output voltage is in between 0-2.1V. Otherwise LED 4 is on. Logic gates[7] are used, to on one led for particular range of output voltage of closed loop amplifier.

III. Equation Derivation

A. Relation between Output voltage, V_{out} and probe resistance, R_p

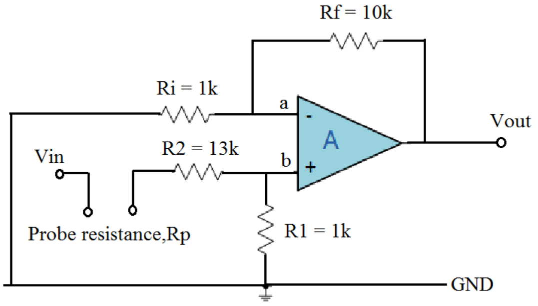

Fig. 3 Experimental Setup for closed loop noninverting amplifier

As inverting (-) input is grounded, so

$V_{out(a)} = 0$

$$V_{out(b)} = V_{in}\left(\frac{R1}{R1+R2+Rp}\right)\left(1+\frac{Rf}{Ri}\right) \quad \textbf{(1)}$$

Hence, $V_{out} = V_{out(b)} - V_{out(a)}$ **(2)**

$$= V_{in}\left(\frac{R1}{R1+R2+Rp}\right)\left(1+\frac{Rf}{Ri}\right) \quad \textbf{(3)}$$

$$= 4.9 \times \left(\frac{0.99}{0.99+12.74+Rp}\right) \times \left(1+\frac{9.78}{0.99}\right)$$

$$= \frac{52.773}{13.73+Rp} \quad \textbf{(4)}$$

B. Relation between fish area and volume of concentration

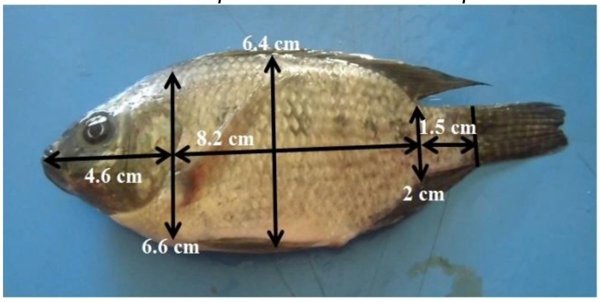

Fig. 4 Medium size Mozambique tilapia fish

For our medium experimental fish (Mozambique Tilapia)-

Area = $\left(\frac{1}{2} \times 6.6 \times 4.6\right) + (8.2 \times 6.4) + (2 \times 1.5)$

$= 70.66\ cm^2$

$= 71\ cm^2$(approximately)

Now,

For $71cm^2$ fish we used 100ml solution

For $1cm^2$fish we used $\frac{100}{71}$ml solution

For Acm^2 fish we used $\left(\frac{100 \times A}{71}\right)$ ml solution

Hence, volume of solution, $V = \frac{100}{71}$ A ml **(5)**

$= 1.4$ A ml **(6)**

IV. Results

For a particular medium size tilapia fish the output voltage for different concentration of formalin –

TABLE I
EXPERIMENTAL DATA TABLE

Types of fish	**Fish Area (cm^2)**	**V_{out} for pure fish (V)**	**V_{out} for 5% formalin in fish (V)**	**V_{out} for 30% formalin in fish (V)**	**V_{out} for 50% formalin in fish (V)**
Mediuma Tilapia	71	1.4	1.72	2.15	2.48

A. By using equation (4) the output voltage is calculated for different concentration of formalin in fish. In the equation probe resistance is used, Rp which is measured by conductivity meter in BCSIR lab.

5ml formalin with fish = 15.5k

30ml formalin with fish = 9.2k

50ml formalin with fish = 7.9k

Theoretical values are almost same with the practical value. The error is calculated by using the following equation-

$$\text{Error} = \frac{\text{Theorecticalvalue} - \text{Practicalvalue}}{\text{Practicalvalue}} \times 100 \qquad \textbf{(7)}$$

Calculated error for different solution is shown in TABLE 2

TABLE 2
THEORETICAL VALUE, PRACTICAL VALUE OF OUTPUT VOLTAGE OF OPERATIONAL AMPLIFIER & ERROR

Concentration of formalin	**Theoretical Value (V)**	**Practical Value (V)**	**Error (%)**
Probe is short	3.88	3.75	3.47
Pure Fish	1.5	1.4	7.14
5ml formalin	1.8	1.72	4.65
30ml formalin	2.3	2.15	6.97
50ml formalin	2.54	2.48	2.42

B. It is observed that output voltage is changed with fish area. For particular percentage of formalin to keep the output voltage fixed the volume of solution is changed by using equation (6). Here the data is taken for 30% formalin in fish, similarly for different percentage of solution it can be measured. Data for 30% formalin is given in TABLE 3.

TABLE 3
OUTPUT VOLTAGE WITH FISH AREA

Types of fish	**Fish Area (cm^2)**	**Volume of solution (ml), for 30% formalin**	**Output voltage**
Mediuma Tilapia	71	100	2.15
Small Tilapia	48	67	2.25
Large Tilapia	108	151	2.19
Hilsa	79	111	2.27
Rui	144	202	2.2
Loytta	68	95	2.05

V. SIMULATION

Simulation of the circuit in ‘ISIS, Proteus 7.10’.

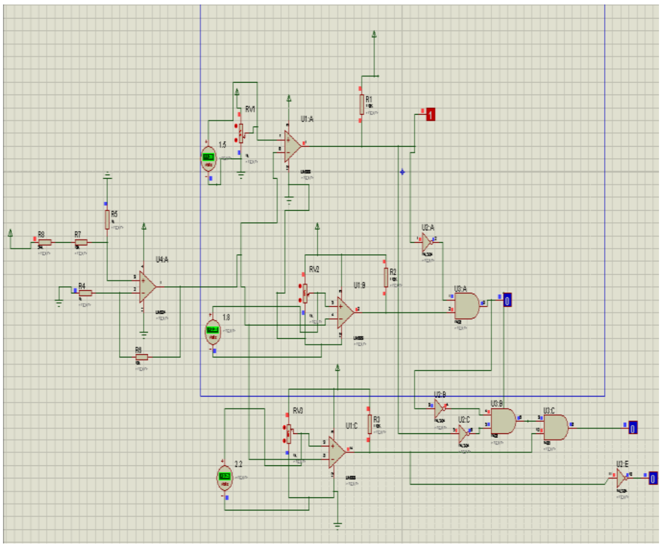

Fig.5 Simulation Diagram

Reference for comparator 1 = 1.5v

Reference for comparator 2 = 2v

Reference for comparator 1 = 2.5v

The simulation results are given in TABLE 4.

TABLE 4

SIMULATION RESULTS

Concentration of formalin	Probes resistance, $R_{p,\ (K)}$	Operational amplifier output (V)	LED ON
Pure Fish	21	1.55	1st LED
5% formalin	15.5	1.82	2nd LED
30% formalin	9.2	2.3	3rd LED
50% formalin	7	2.55	4th LED

VI. IMPLEMENTATION DIAGRAM

The circuit has been implemented in bread board.
For pure fish LED 1 (white), for 5% formalin in fish LED 2 (green), for 30% formalin LED 3 (red), for 50% formalin LED 4 (white) is on.

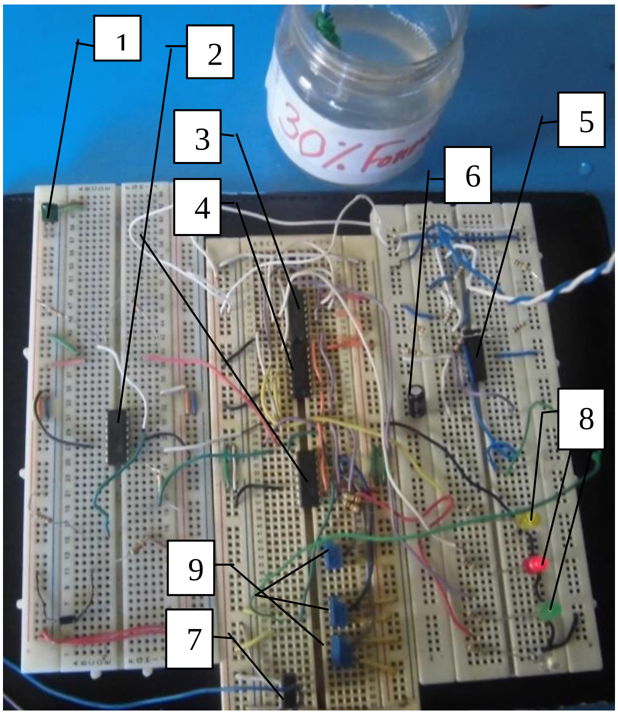

Fig. 6 Implementation Diagram

1. Capacitor(100 µF)
2. LM 339
3. IC 7408
4. IC 7404
5. LM 339
6. Capacitor(100 µF)
7. IC 7805
8. LEDs
9. Variable resistors

VII. RESULTS AND ANALYSIS

1. Resistance of formalin in water

5% formalin = 11.11k 30% formalin = 7.7k

50% formalin = 6.7k 80% formalin = 5.9k

100% formalin = 5.5k

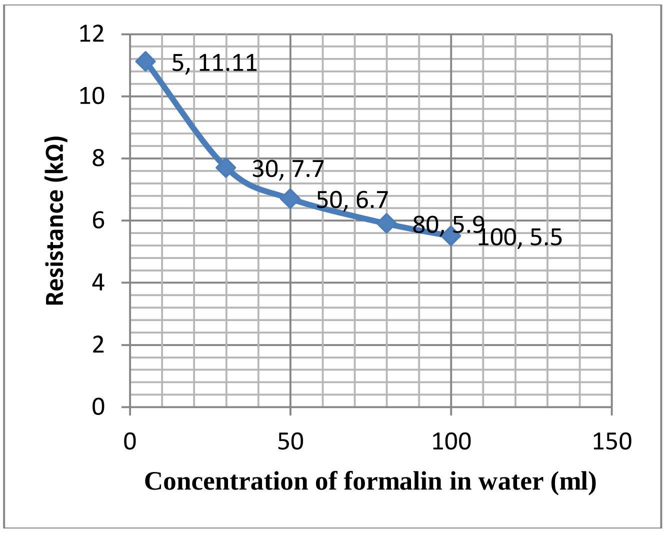

Fig. 7 Resistance vs Concentration formalin in water

In the graph 7 it is observed that, resistance of solution is decreasing with the increase of concentration of formalin in water. So, the relation between resistance and concentration of formalin in water is inverse.

2. Resistance of formalin with fish

5ml formalin with fish = 15.5k

30ml formalin with fish = 9.2k

50ml formalin with fish = 7.9k

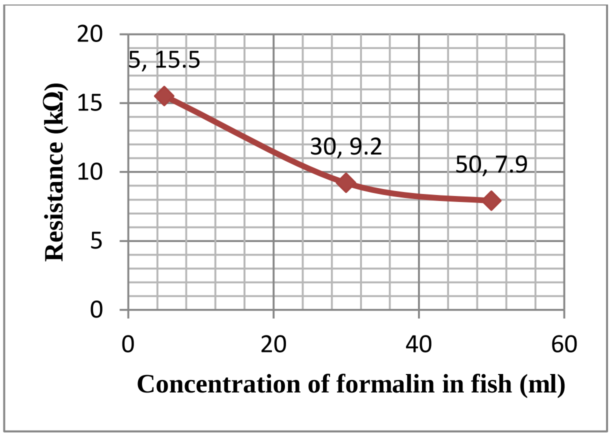

Fig. 8 Resistance vs Concentration of formalin in fish

In the graph 8 it is observed that, resistance of solution is decreasing with the increase of concentration of formalin in fish. So, the relation between resistance and concentration of formalin in fish is also inverse.

3. Change of output voltage with formalin concentration

5ml formalin with fish, output voltage of amplifier = 1.72V

30ml formalin with fish, output voltage of amplifier = 2.15V
50ml formalin with fish, output voltage of amplifier = 2.3V

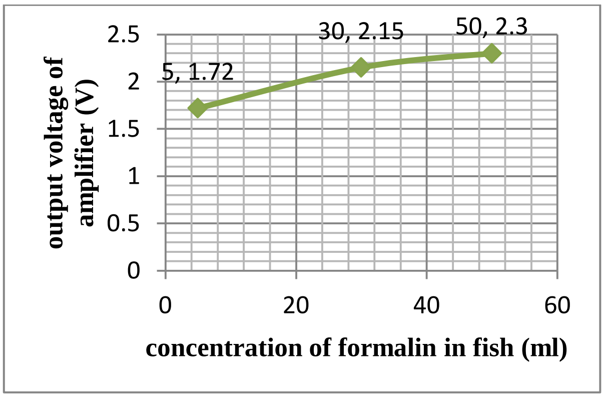

Fig. 9 Output voltage of amplifier vs Concentration of formalin in fish

In the graph 9 it is observed that, output voltage of amplifier is increasing with the increase of concentration of formalin in fish. So, the relation between output voltage of amplifier and concentration of formalin in fish is proportional.

VIII. FUTURE WORK

1. In this project the presence of formalin has been shown in three levels. It can be shown in percentage.
2. Formalin detection in milk, vegetables are also possible with little modification.
3. Error can be reduced by using low tolerance resistors.

IX. CONCLUSION

This paper has demonstrated how to detect formalin in food items. It has some advantages. First of all, the price of this kit is very low compared to the existing device, so that people can easily access to it. Besides, the use of this kit is also easy and people can easily use it. It is also observed that, the difference between the theoretical values and practical values is quite negligible thus ensuring the accuracy of our kit.To ensure the accurate result, some things must be checked carefully. The space between the two probes must be constant for all tests, otherwise the resistance will be changed with the change of space between probes. After every test, the probes should be cleaned with pure water. Reference voltages of the three comparators should be checked before test. The test should be done immediately after preparing the solution otherwise the result may be incorrect.

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