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Measurement of Hardness of Water Using Capacitance Based Sensor

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Abstract: - **Salinity measurement is important because it plays a significant role in measuring subsequent parameters like density, etc., This method describes a method to measure the salinity of water using a capacitive transducer which has two parallel plate electrodes. The electrodes are immersed continuously in the water so that the area and distance between the plates don't change. The change in capacitance is converted to a proportional voltage using Schering bridge. This can be analyzed under various conditions before making into a handheld device where the data can be stored. This method is simple and reliable which can be used for industrial purpose.**

Key words: - **Salinity; Capacitive transducer; Schering bridge.**

I. INTRODUCTION

Salinity is the measure of amount of salt present in water. It is normally presented in parts per thousand (ppt). It is an important parameter to be measured for determining the sea water equation of state. The Salinity of sea water increases with increase in evaporation of water. There were different methods proposed for measuring salinity of water. Horia-Nicolai L. Teodorescu et al developed a method to measure salinity of water using sensors based on chaos dynamics produced in non linear dynamic circuit. Linh Viet Nguyen et al proposed a method for finding water salinity by using a fiber sensor. The sensor is based on three - wave fiber Fabry- Perot interferometer fabricated in a single mode optical fiber. Generally fibre sensors measure the refractive index to measure salinity. Therefore high sensitivity sensors must be used. Darcy J. Gentleman et al proposed a method to determine the salinity using multimode fiber optic surface Plasmon response dip-probe which measures salinity with an accuracy of less than 200ppm salinity. Xavier Chavanne et al developed a meter for measuring salinity by measuring admittance using a bridge. Yipeng Liao et al proposed a method with Microfiber MZ Interferometer with a Knot Resonator. Our method will be attractive since it is a low cost, simple method to determine salinity.

II. METHODOLOGY

The capacitive method of measuring the salinity consists of parallel plate electrodes which are made of non corrosive materials separated by free space. The equation of capacitance of a parallel plate capacitor is is $C = \varepsilon 0 \varepsilon r A/d$. The change in dielectric medium produces capacitance. But in this case the sensor is immersed constantly in the water. Therefore there will be no change in area and distance between the plates. Various dielectric medium will produce various capacitance which will be proportional to the concentration of the solution. The capacitance measured is displayed in the LCR meter. The capacitance is further converted into voltage by using Schering's bridge. The Schering bridge is an electrical circuit used for measuring the insulating properties of electrical cables and equipment. It is an AC bridge circuit developed by Harald-Schering. The Schering Bridge is used to find the unknown capacitance and convert it to proportional voltage by using the balance equation. It has the advantage that the balance equation is independent of frequency. By calibrating the arms we can balance the bridge to null condition initially using a buffer solution. Whenever the relative permittivity changes, the capacitance changes and a small amount of output is obtained from the bridge. The readings are recorded along with the pH and phase angle variations corresponding to the change in salinity (Table 1)

III. RESULTS

The sensor is calibrated with plain water and plain water + 0.2g of NaCl solution. Specification for both reference solution is shown in Table 1.

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	REFERENCE 1	REFERENCE 2
SOLUTION:	Plain Tap water	Plain tap water +0.2g Nacl
ELECTRODE:	Co-axial OHIH-50	co-axal OHIH-50
DIP :	2 cm	2 cm
R4:	15 kΩ	23kΩ
C4:	0.331µF	0.1µF
SB(v):	0.021v	0.062v
LCR:	39.11µF	67.89µF

Table 1: Specification of bridge values and reference solution for calibration

The sensors are tested with both reference solution.The LCR meter reading is recorded and corresponding bridge voltages are obtaines using signal conditioning unit.Each sample tested.

S. NO	SOLUTION	LCR READING (µF)	SB UNBALANCED VOLTAGE(v)		pH	Θ (deg)
			REF 1	REF 2		
1	100ml water + 1g Nacl	77.96	0.867	0.102	9.32	-51.77
2	100ml water + 5g Nacl	89.785	0.887	0.131	8.96	-50.31
3	100ml water + 10g Nacl	100.98	0.955	0.205	8.69	-57.27
4	100ml water + 15g Nacl	122.98	0.993	0.285	8.57	-52.88
5	100ml water + 20g nacl	145.7	1.038	0.33	8.4	-48.99
6	100ml water + 25g Nacl	170.89	1.007	0.321	8.32	-38.4
7	100ml water + 30g Nacl	164.98	1.006	0.312	8.2	-35.08
8	100ml water + 35g Nacl	204.78	0.998	0.325	8.18	-26.62

The linear increase in the capacitance value in reference to the 0.2g of Nacl+ Water solution is shown in Figure 1.

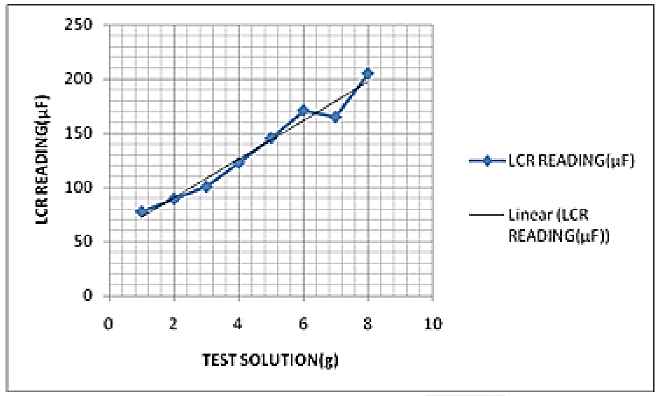

Figure.1 LCR reading vs Test solution

This value of voltage obtained from Schering Bridge is directly proportional to this capacitance.The results of the Figure.2 clearly states that the reference solution with plain tap water+0.2 of NaCl can be used for preceding the experiment. The experiment is done and the voltage is obtained.

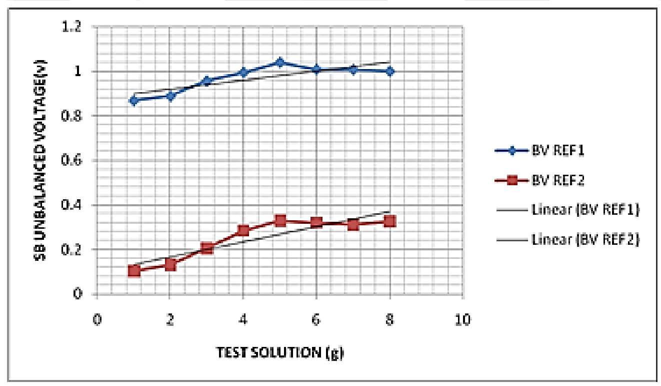

Figure.2 SB unbalanced voltage vs Test solution

The method has a simple circuit for determining the salinity. The variation of pH with the 0.2g of Nacl solution is depicted in graph shown in Figure 3. The pH initially increases and gradually decreases towards the centre of the spectrum

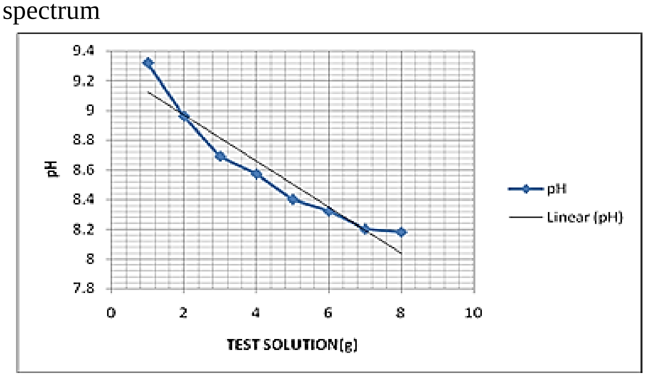

Figure.3 pH vs Test solution

Figure 4 represents the increase in phase angle with respect to the reference solution. The phase angle increases with increase in the amount of NaCl being added.

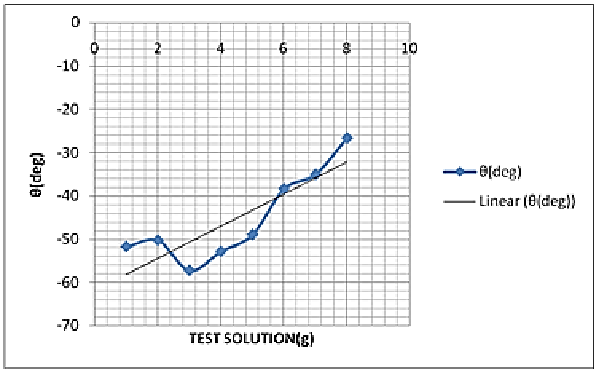

Figure.4 Phase angle vs Test solution

IV. DISCUSSION

The results of the above Figure.2 clearly states that the reference solution with plain tap water+0.2g of NaCl can be used for proceeding the experiment. The method has a simple circuit for determining the salinity. The project can be further improved by displaying the voltage reading in a display using microcontroller. This can be done by analyzing the capacitance change under various circumstances like different temperatures etc., on comparing with the experiment done with multimode fiber optic surface Plasmon response dip-probe, the results obtained is more accurate.

V. CONCLUSION

The proposed method is evident to find the salinity with accuracy of 0.2mg/ml, this method is highly reliable. It is also observed that there is a linear increment in the capacitance measured using LCR meter. This method can be further modeled into a handheld device which will be easy to carry and measure. Thus the proposed method can be used in the application where the hardness of the water needed to be measured continuously.

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