OPEN ACCESS
Saudi Journal of Engineering and Technology
Abbreviated Key Title: Saudi J Eng Technol
ISSN 2415-6272 (Print) |ISSN 2415-6264 (Online)
Scholars Middle East Publishers, Dubai, United Arab Emirates
Journal homepage: https://saudijournals.com

Original Research Article

Design and Construction of an Electronic Salt Tester

Idim AI[1*], Iyere SF[2]

[1]Department of Electrical and Electronics Engineering, Petroleum Training Institute, Effurun, Nigeria
[1]Department of Electrical and Electronics Engineering, Ambrose Alli University, Ekpoma Nigeria

DOI: 10.36348/sjet.2021.v06i10.003 | **Received:** 29.08.2021 | **Accepted:** 01.10.2021 | **Published:** 12.10.2021

***Corresponding author:** Idim AI **Email:** [1*] idim_ai@pti.edu.ng, Sunday4success2007@aauekpoma.edu.ng

Abstract

This research study focuses on the design and construction of an electronic tester using locally soured materials for measuring the concentration of table salt in solution. Salt, also known as table salt is a mineral that is composed primarily of sodium chloride (NaCl), this is a chemical compound belonging to the large class of ionic salts. The operating system consists of sensor, which senses the concentration of salt in solution, the signal amplification unit, which amplifiers the signal from the sensing unit and the display unit, which displays the concentration of salt in various solutions. The realization of the research study was achieved using different components like resistors, capacitors, op-amp, CA3162E, CA3161E and seven segment display. The design parameter was obtained from component calculations configured with the amplification unit to work with the sensing and display unit. These components were connected together on a veroboard with the aid of different tools. After completion of work, the project was tested and the percentage error values obtained by dipping the sensor in salt concentration were 0.58, 1.43, 1.73, 2.10, 2.21 respectively, which was relatively low compared to other electronic salt tester.

Keywords: Electronic Salt Tester, Sodium Chloride (NACL), Sensor.

1. INTRODUCTION

One of the most precious gifts from God to mankind is salt and it is affordable at a very cheap rate by everyone. Salt, also known as table salt is a mineral that is composed primarily of sodium chloride (NaCl) a chemical compound belonging to the large class of ionic salts. It is essential to human in small quantities, but harmful in excess [1]. The maximum daily salt consumption by human is 6g per day for age 11 and above, 5g per day for age 7 to 10,3g per day for age 4 to 6 and 2g per day for age 1 to 3. Salt help in regulating fluid balance of the body. Because of its importance to survival, it has often been considered as valuable commodity in human history however too much salt expose man to various health hazard such as muscle cramps, dizziness, high blood pressure, Edema, stomach cancer, stroke and cardiovascular disease [2]. Therefore the knowledge of salt concentration is very important in our daily life. Man uses his sense organ which is tongue to carryout judgment on salt concentration. This varies from man to man. This judgment is unreliable. In other to avoid these irregularities, the project is aimed at designing and constructing a salt tester which can measure the concentration of salt in various liquid substances [3, 4]. The operation of the salt tester is subdivided into various sections as shown by the block diagram.

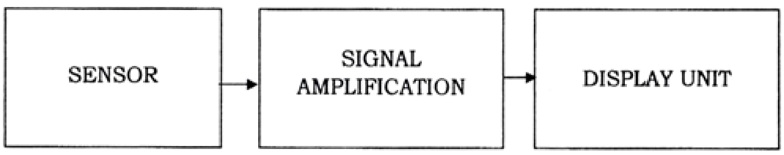

Fig-1: Block diagram of a salt tester

1.1. Sensor and Display Unit

Sensor is a device that detects change in measured variable (salt) and converts such change to its electrical equivalent hence it serves as a transducer. The signal from the sensor is very weak so the signal is being amplified in this section by increasing its amplitude. The signal amplification is done with an amplifier [5]. The signal from the amplifier is being displayed by this unit to indicate the various concentration of salt at different grams. The aims and objectives of this research include to: measure the salt concentration of liquid substances containing salt; assist individuals to manage salt level in the body; help to control salt concentration in liquid food [6, 7].

1.2. Applications

The use of salt is unquantifiable: It is used in hospitals to control diet of patient; it is used by companies manufacturing drips; it is equally useful in manufacturing industries for producing soap and detergents; It is useful in applied in chemistry laboratory for measurement of salt concentration in solution [8].

The NPN transistor has a forward biased emitter - base junction and reverse biased collector base junction. The forward bias causes the electrons in the N - type emitter to flow towards the base. This constitutes the emitter current (I_E). These electrons flow through the P-type base, they tend to combine with the holes. Since base is slightly doped and very thin, only few electrons combine with the holes to constitute base current (l_B), the remaining electrons cross over into the collector region to constitute the collector current (l_C). In this way almost the entire current 1lows in the collector circuit [9]. Hence, it is clear that the emitter current is the sum of base and collector current. The PNP has a forward biased emitter -based junction. The forward bias causes the holes in the P-type emitter to flow toward the base. This constitutes the emitter current I_E. As these holes cross into N-type base, they tend to combine with the electrons. As the hole is lightly doped and very thin therefore, only a few holes combine with the electrons. The remainder cross into the collector region to constitute collector current I_C. In this way almost the entire current flows in the collector circuit [10].

2. MATERIALS AND METHOD

2.1. Design and Displacement Unit

The design of the salt tester was carried out in stages. These stages are discussed in the various sections. The display unit consists the ADC (CA3162), the decoder driver (CA316lE) and the seven segment display unit.

From manufacturer's specification
R_{10} = 1OKΩ

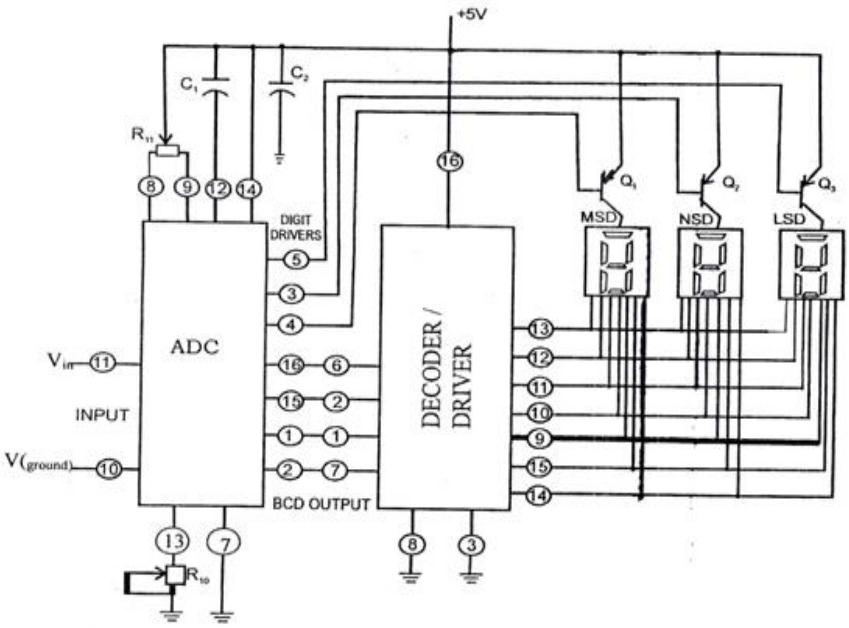

Fig-2: The Display and Displacement Unit of the System

R_{11} = 50OKΩ
C_1 = 0.27uF
C_2 = 0. 1uF
C_1 serves as integrator in the ADC while C_2 smoothen the power supplied to the ADC. Refer to Appendix for manufacturer's Specification.

As shown in Figure 2, the transistor connected to the display serves as a switch that switches the required display corresponding to the BCD code from the driver. The transistor used is BC557. The transistor is a PNP transistor. The reason for choosing PNP transistor is because the seven segment display is connected in common anode [8]. Since a high is at the anode, the transistor must be saturated for the display to work. Furthermore BC557 has maximum collector current rating of 10OmA and each seven segment need a current of 49mA. See appendix III for manufacturer's data sheet of BC557. Choice of ADC- CA3162 was chosen because of the following reasons.

It produces BCD code

- Capable of reading 0-9v
- Low speed because it does not require high frequency
- Differential input because any pin either 11 or 10 can serve a input.

Choice of Driver: The CA3161 was chosen because of the following reasons;

- Produces 25mA constant current segment outputs
- Eliminates need for output current limiting resistor.
- Low standby power dissipation (18mW)

2.2. Design Choice of Amplifier

The signal amplification is done with the aid of an instrument amplifier. The instrument amplifier used is LM324. The LM324 was chosen because of the following reasons: High input impedance**;** **l**ow input offset**;** **h**igh common made rejection ratio**;** **l**ow power**;** **l**arge DC voltage gain**;** **i**ntended application**.** The instrument amplifier is shown in Figure 2. 6g is the maximum daily requirement for human for healthy living. In converting the change in concentration to voltage a reference voltage is assigned to one probe [9]. From measurement salt concentration with respect to voltage is shown in table 3.0.1.

Table-3: Salt concentration with respect to voltage

MASS OF SALT	VOLTAGE ACROSSS PROBE
6g	6mV
5g	5mV
4g	4mV
3g	3mV
2g	2mV
1g	1mV

Sensor Unit: In converting the change in concentration to voltage, reference voltage was assign to one probe. For the ADC to be able to interpret the concentration of solution to voltage, the reference probe in supplied with maximum reference voltage of 6mV.

3 TESTING

3.1. Construction Procedure

The construction of the circuit was done according to the following procedures: The electronic component was first assembled, tested, connected on a breadboard and the connection was tested to ensure effective connection as well as effective modification on the circuit; after the breadboard experiment, the component was transferred to a veroboard; the layout of the component was done to be very compatible so to reduce the use of long connecting leads in the construction; the component was properly soldered to ensure proper connection; after construction of the circuit, all connecting points where tested to ensure continuity.

3.2. Mode of Operation

The operation of the project is based on the conductivity of salt is solution. When salt is poured into water, alter some seconds the salt is fully dissolved in the water and its ions becomes mobile. The probes are dipped into the salt solution and are placed at equal distance from each other. The movement of ion constitutes the conductivity of the solution. The movement of ion results in current flow but as a result of resistance of the salt in solution, there exist voltage drop across the probes. As salt concentration is increased through addition of more salt in solution, the voltage across the probes continue to increase. The change in voltage is equivalent to the changes in the concentration of salt. The change in voltages is send to the amplifier for amplification.

The amplifier amplifiers the difference in voltage between probe (one probe is at a higher potential compared to the other) and sends signal to the ADC. The ADC converts the signal to a digital readout which is then send to the decoder /driver. The driver decodes the signal and at same time drives the seven segment display to display the equivalent Concentration of the salt. After constructing the electronic circuit, it was cased using an adaptor box made with plastic.

3.3. Operational Test

Testing was carried out by putting of salt in water and after 10secs the probe were dipped into it. The display displays the concentration corresponding to the quantity of salt poured in the water. Several quantity of salt was put into water and various concentrations were displayed at the output.

Table-5: Result of the Performance Test

s/n	Mass of salt	Calculated concentration value (M/mL)	Display concentration value		Percentage error
			Value on display (M/mL)	Actual value (M/L)	
1	1g	0.17	171	0.171	0.58
2	2g	0.35	345	0.345	1.43
3	3g	0.52	511	0.511	1.73
4	4g	0.68	666	0.666	2.10
5	5g	0.86	841	0.843	2.21

3.4. Observation and Precaution

It was observed that when the probe touches in the concentrated solution, the voltage drop was zero. I also observed to prevent 1C socket was used in the construction to prevent IC from being over heated during soldering. The stability of solution and temperature of the environment affects measurement of concentration; hence, it is difficult to display concentration of salt above 5g with 100mL of water because of the display used. Since different grams of salt was used for same volume of water, once the solution becomes saturated it will yield no result at the output.

4. CONCLUSION

The electronic salt tester assists in quick and approximate indication of the salt content in diets. Hence, is recommended in controlling salt intake for ailment prevention. In addition, the salt tester is used in physics and chemistry laboratories to detect salt concentration in solution and also to check the salinity of soil. The sensitivity and display should be improved so that the device can work for large volume of solution.

REFERENCES

1. Akusoba, E. U., & Ewelukwa, G. O. (2006). Calculations in chemistry for senior secondary schools.
2. Gupta, J. B. (2002). Electronic and Electrical measurements and Instrumentation. *SK Kataria and sons*.
3. Omowaye. F. N. (2009). Guide to Electronics (Projects Made Easy)
4. Andreev, N., Ronteltap, M., Boincean, B., Wernli, M., Zubcov, E., Bagrin, N., Borodin, N., & Lens, P N L. (2017). Lactic Acid Fermentation of Human Urine to improve it's Fertilizing Value and Reduce Odour Emissions. Journal of environmental management, 198.
5. Cotton, S. (2011). Coca Cola. Education in Chemistry. Royal Society of Chemistry. https://eic.rsc.org/soundbite/cocacola/2021233.article Accessed June 1, 2019
6. Georgi, D. (2006). Metal-Air Batteries, Half a Fuel Cell?. Excerpts from the Proceedings of the 42nd Power Sources Conference: 12- 15 June 2006,
7. Helmenstine, A. M. (2019). What Is the Chemical Composition of Vinegar? Thought Co., https://www.thoughtco.com/chemicalcomposition-of-vinegar-604002 Accessed June 5, 2019 IEA (2019).
8. Global Energy Demand Rose by 2.3% in 2018, Its Fastest Pace in the Last Decade. International Energy Agency (IEA). https://www.iea.org/newsroom/news/2019 /march/global-energy-demand-rose-by-23- in-2018-its-fastest-pace-in-the-lastdecade.html Accessed June 2, 2019 IEA (2017).
9. Energy Access Outlook. (2017). From Poverty to Prosperity. International Energy Agency. IPCC (2012). Renewable Energy Sources and Climate Change Mitigation. Special Report of the Intergovernme
10. Susanto, A., Baskoro, M.S., Wisudo, S.H., Riyanto, M., Purwanka, F. (2017). Performance of Zc-Cu and Al-Cu Electrodes in Seawater Battery at Different Distance and Surface Area. *International Journal of Renewable Energy Research*, *7*(1)