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# Design and Construction of Solar Powered/ Rechargeable Electrophoretic Machine

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## Abstract:

*For many years, people died of diseases they have no idea of, nor know how to cure it, such as sickle cell (SS) anaemia which is caused by the ignorant of genotype selection by married couples. The advent of electrophoretic machine has bridged the gap but power failure hindering the effectiveness of such machine. The study considered an alternative source of power to the electrophoretic machine. The work designed and constructed an interruptible means of power supply to electrophoretic machine, in order to enhance its effectiveness at all times. The work considered the availability of sun light to generate power and the ability of battery to retain charged current. A modeled circuit that will regulate power from the solar panel/rechargeable battery to the electrophoretic machine was developed. The work demonstrate the system by monitoring the sample separation time. The project constructed in a way that professional can possess and operate it. It shows how each components of the machine work. This work has successfully demonstrated how energy from the sun and other electronic components such as rechargeable battery, diode, resistors, and capacitor can be used to actualize a fascinating output. The study shows 90% solar powered electrophoretic machine function. The project consists of solar panel, rechargeable battery, vero board, resistors, diodes, capacitors, glue, plastic board and voltage regulator. These materials were locally sourced, economical, reliable, safe, fast and available.*

*Keywords* **—DNA,Electrophoresis, genotype**

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## I. INTRODUCTION

Many couple witnessed sudden death of their child at birth or at their teen, without knowing the cause or how to avert it. Some in the remote areas refer to it as 'Ogbanje' because there is no electricity to power electrophoretic machine in order to carry out the test of genotype of couple before they start bearing children. The advent of the knowledge of electrophoresis threw light on the genotype constitution of cells.

Electrophoretic machine is a machine used in detecting the genotype of human being which basically is AA, AS, SS. This describes the migration of a charged particles under the influence of an electric field which is known as Electrophoresis.

is used to determine the quality of extracted nucleic acids. DNA is a negatively charged molecule and therefore will migrate towards the positive anode in the presence of an electric field in an electrolyte solution, and differential mobility is determined by size (Scull, 2014).Various essential biological molecules, such as amino acid, peptides, protein, nucleic acid nucleotides, have ionizable group which at given PH exist in

  

solution as electrically charged species either as cathode(+ve) anion(-ve ) . The separation effect on the ionic particles results from differences in their velocity(V),which is the product of the particle's mobility(m) and the field strength (E)

V = mE

Electrophoretic conditions are characterized by the electrical parameters (current, voltage, power) and factors such as ionic strength, PH value, viscosity, pore size etc. which describe the particles are moving.

**Aim and Objectives**

The majoraim of this project is to design and construct a Solar Powered/rechargeable Electrophoretic Machine that will be serving 24 hours 7 days in a week without interruption. Objectives of this study are:

i. To review and improve on the present electrophoretic machine that cannot work without using electricity or big generator.
ii. To design and fabricate a Solar Powered/rechargeable Electrophoretic machine that can be un-interruptible
iii. To construct a simple and handy electrophoretic apparatus that can be functioning round the clock.
iv. To construct the electrophoretic tank that is small, fast and active in analysing samples.
v. To design an electrophoretic machine that will be affordable, available, safe, easy to operate and user friendly.

**Statement of the problem**

Most remote areas have no access to electricity or suffer epileptic power supply, health professionals in such areas find it difficult to carry out simple diagnoses like genotype, blood group,. Here a power backup is quite practical by adding a rechargeable power source to sustain the work flow. Constructing a power regulating circuit to manage power during separation process. It becomes imperative to use the energy of sun to generate powerone can carry along to any place for diagnoses. The major problem encountered in the process of constructing this circuit was to generate enough voltage that can separate the sample which was overcome by the use of LM317T variable power supply, the other encounter was the spacing between the electrodes. This test and check was performed severally until a desired result was achieved.

**Significance of the study**

The use of engineering approach to design and construct solar based rechargeable power system using solar panel to generate direct power which is stored in a rechargeable battery, this has of great deal reduced the effect of epileptic power supply and also checkmate weather effect during bad weather the rechargeable batteries serves as power backup.

The advantages of this locally made electrophoretic machine are that:

i. It reduces the all dependent on electricity.
ii. Minimize the health hazard of noise pollution from generator.
iii. To encourage health care personnel ie medical laboratory scientist to operate at any remote place.
iv. Cheap in the cost of production due to the purchases of the components within our locality.

However, the circuit is designed to be operated by any health professional, it will not need to be programmed or synchronized before proper operation. It is user friendly. It will be used or operated at any remote place without electricity and at all weather.

**Limitation and scope of the study**

Since this project is basically design to use solar energy, the limitations are: The initial cost of purchasing a solar system, which include solar

  

panel, batteries, etc. Solar panels dependent on sunlight to effectively gather solar energy, therefore, a few cloudy, rainy days can have a noticeable effect on the energy system. Solar energy cannot be collected during night.

## II. DESIGN ANALYSIS

### Materials

The major materials needed for the construction are: Resistors; Regulator LM317T; Filter capacitor 400v 33uF; Rectifier or Diodes; Pilot lamp; Power switch; Rectangular Metallic Casing /box; Power cord, AV cable and connecting cables; Outlet; Fuse and fuse holder; Vero board; Soldering machine and soldering lead and Spray paint.
The materials for the tank are: PVC plastic; Super glue; Cutter; soldering lead and AV female port.

### Other Components

**Solar Panel:** A Solar Panel or voltaic module is an assembly of photo-voltaic cells mounted in a frame work for installation. Solar panels use sunlight as a source of energy and generate direct current electricity.
**Switch:** Switch is an electrical component that can break an electrical circuit, interrupting the current or diverting it from one conductor to another.

**Indicator Light:** This is an electric device that gives signal in light form to indicate that the machine is working or functioning. Indicator light can be of different colors; example red, orange, pink, etc. and it can be different shapes.

**Fuse:**In electronics and electrical engineering, a fuse is a type of low resistance resistor that acts as a sacrificial device to provide overcurrent protection, of either the load or source circuit.

**Resistors:** Resistors restrict the flow of electric current, for example a resistor is placed in series with a light emitting diode [LED] to limit the current passing through the LED. Resistors are common elements of electrical networks and electronic circuits and are ubiquitous in electronic equipment.The resistor color code and color number or coding. The following table shows the colours used to identify resistor values.

**Table 1:** The Colours Used to Identify Resistor Values

| COLOR | DIGIT | MULTIPLIER | TOLERANCE | TC |
|---|---|---|---|---|
| Black | 0 | x 1 □ | | |
| Brown | 1 | x 10 □ | ±1% | ±100*10$^{-6}$/K |
| Red | 2 | x 100 □ | ±2% | ±50*10$^{-6}$/K |
| Orange | 3 | x 1 k□ | | ±15*10$^{-6}$/K |
| Yellow | 4 | x 10 k□ | | ±25*10$^{-6}$/K |
| Green | 5 | x 100 k□ | ±0.5% | |
| Blue | 6 | x 1 M□ | ±0.25% | ±10*10$^{-6}$/K |
| Violet | 7 | x 10 M□ | ±0.1% | ±5*10$^{-6}$/K |
| Grey | 8 | x 100 M□ | | |
| White | 9 | x 1 G□ | | ±1*10$^{-6}$/K |
| Silver | | x 0.01 □ | ±10% | |
| Gold | | x 0.1 □ | ±5% | |

*Source:* (Aston, 2010).

## III. DEVELOPMENTAL PROCEDUREE

The following operations were performed sequentially in order to produce this locally made electrophoretic machine:

**For Machine:** Circuit diagram; Marking out; Insertion of components; Assembling components; Circuit connection; Coupling and Painting or final touching in the external body.

i. **Circuit Diagram**: this shows in detail of how the inter connections between components in the board will be made and followed.

ii. **Marking Out:** this process of marking out involves the use of marking out instrument such as scriber and so on to measure and mark desired size on the Vero board.

iii. **Insertion:** this process involves the insertion of the required components into the Vero board according as described in

  

the circuit diagram immediately after I finished the marking out.

iv. **Assembling:** it also involves bringing different components part together as one.

v. **Circuit Connection:** this process involves the use of connecting cables to joining the different component parts together as required in the circuit diagram. After my insertion and assembling of the components, I used the connecting cable to connect them together in order to allow free flow of current.

vi. **Coupling:** this process involves coupling the cubic box together, after the whole connections must have been done, I covered the cubic box and I coupled it.

vii. **Painting or Finishing Touches:** this machine was painted to prevent it from rusting which will lead to corrosion of the metal surface.

**Power Supply Unit:** Almost all the electronic circuit from simple transistor and operational amplifier circuit up to digital and microprocessor systems requires one source of stable voltage. A regulated power supply can be constructed by using negative feedback to compare the dc output voltage with a stable reference voltage.

The transformer normally, changes the mains supply voltage to a value which is safe to work with and somewhat more than the wanted dc voltage but which is not more than that the regulator can handle. But because a voltage of not less than 200V is needed for this project, a two-winding transformer which is same as auto-transformer in function is adopted for the transformer stage.

The transformer output is rectified using a bridge rectifier producing fluctuating d.c voltage which is then passed through a filter capacitor. The filter is required to remove the ripple voltage of frequency equal to twice mains frequency for bridge rectification. The filter is basically a shunt electrolytic capacitor that charged up the peak value of the input voltage with a large discharge time to prevent it been completely discharged when the fluctuating d.c voltage is going low. Hence, there is always a voltage output across any load connected. The output voltage from the filter is then fed into a linear regulator whose rating is compatible to handle this voltage.

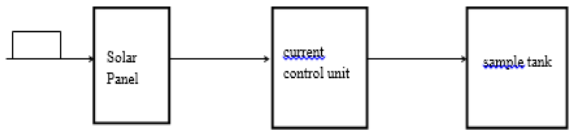


**Figure .1:** Block Diagram

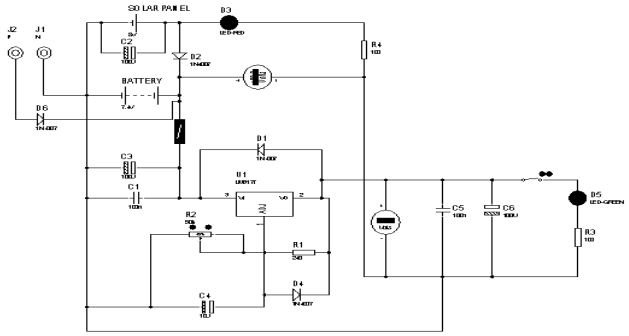


**Figure .2:** Circuit diagram of Voltage Control System

$$Rx = \frac{1.25}{Charging\ current} = \frac{1.25}{40AH} \quad \frac{1.25}{4}$$

$$= 0.31\text{ohm} \quad - \quad - \quad (1)$$

$$Ry = \frac{total\ watts}{volt\ Rxy} = \frac{40}{12}$$

$$= 3.3 \quad - \quad - \quad - \quad (2)$$

**Theory of Operation**

When the circuit is powered by closing switch, the diode D1, D2, D3, D4 converts A.C current to D.C current. The voltage from the D.C output still contains some degree of ripples. These

ripples are further removed by the capacitor through the current flow through the transformer. This is a better D.C output but not totally free of ripples. It is then fed to the voltage regulator which not just reduces the final output of the power supply but also keeps it constant which is now suitable for proper operation of the tank. The resistors works with the regulator (switches to regulate voltage flowing into the tank).

The output which is connected to the tank energies for separation in the tank (separation of blood samples in the tank).

**Summary**: Electrophoresis machine is a machine used in detecting the genotype of human being which basically is AA, AS, SS.

Formerly, electrophoretic was constructed without the use of resistors. But today, due to advancement in electronic chips, electrophoresis machine has metamorphosed into sophisticated devices that have the capacity to separate blood and classifying them into types, example AA, AS, SS. Locally, electrophoretic is typically made of large plastics or metallic cubic box. The plastic will be cut in such a way that there will be division that will separate the tank from the engine or two cubic boxes and one serving as the tank and the other, the engine.

Most locally constructed electrophoretic machine do not make use of resistors and this cause a lot of damage to the machine electrically and functionally. Electrically, it can destroy the diode due to high voltage and functionally, it can tear the cellulose acetate paper in the separation tank.The advantage of this locally made electrophoretic machine is that it is cheap in the cost of production due to the purchases of the components within our locality.

## IV. TESTING AND TROUBLESHOOTING

If the project passes all the tests, then it is ready for use.

**Preliminary testing** is done first. This area performed before power is applied to the project. This is to detect errors that could cause serious problem should the wrong voltage and current be allowed to reach critical components. Preliminary testing is preventive testing.

Once the project passes all preliminary test, **operation test begins**. Here, power is applied for the first time and basic project functioning is determined if all appears well at this point, performance testing is done. If there is a problem, say voltage is not reaching the tank [that contains the blood samples] or malfunctioning the project must under goes the trouble shooting stage.

**Troubleshooting** is done to determine what is wrong, why it is wrong and what to do about it. There the cause of the problem is identified and corrected and next is the performance testing.

**Performance testing** is used to determine if the project will work whenever and where ever it is supposed to be used. With performance test, the work is subjected to harsh and extreme condition. This project work has been subjected to extreme voltage of 200-220v for about two hours.

### Troubleshooting

It is difficult to generalize about component failure. The point is depending on the problem, some components are more likely to cause trouble than others. Most likely fail components are capacitors, diodes, and transformers. While least likely to fail are the resistors.

To troubleshoot this work whenever any problem occurs, the following stages are taken.

i. Does the indicators light turn ON? If NO, then check the power supply unit. Test the output of the regulator, for the proper output voltage of 7.5V, if no voltage, check polarities of regulator and rectifiers if the answer is still no, then check the 7.5V A.C outlet.

ii. Does the converter (diode) passes direct current? If no, check the diode with the multimeter to rectify if it is good. If it is good then check the soldering if all the cores are well connected.

  

If everything is ok, then check the capacitor if the voltage has damage to it.

## V. RESULTS AND DISCUSSION

**Tank Operation:** As for genotype, blood sample will be required for the operation, and AS will be used as a control for the test. (AS blood sample is the determinant factor). Tris buffer of 8.7pH is poured into the tank that contains the soldering lead, cellulose acetate paper is allowed to soak with the buffer for at least 10 minutes. Acetate paper should be cleaned to avoid excess soaking of the buffer. The blood samples that are unknown will be placed in a straight linear form with the control (AS). The sample migrates from positive to negative terminal. The AS sample will be placed on top of the cellulose acetate paper alongside with the unknown sample linearly. When the machine is powered, the will be a separation from the positive to the negative pole in which the 'S' migrates faster then followed by the 'A', which is the determining factor. The unknown samples will migrate is required. If the unknown samples lies below the A band, the genotype is AA. If the unknown sample lies below the S band, the genotype is SS, also if it lies below both the A and S bands, then the genotype is AS.The current from the circuit will allow the flow of negative and positive current in the tank thereby causing separation of the samples.

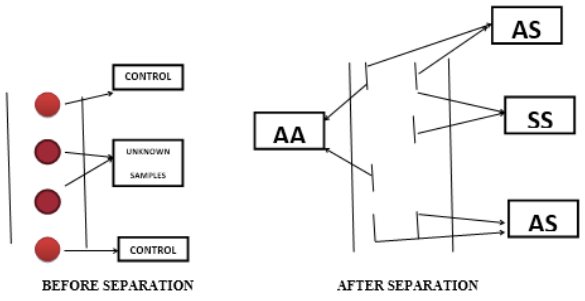


**Figure 3:** Control and Unknown Samples practical manual for health center in eastern Arica AMBEF.

**Performance Evaluation**

Performance testing is used to determine if the project will work whenever and where ever it is supposed to be used. With performance test, the work is subjected to harsh and extreme condition. This project work has been subjected to extreme voltage of 200-220v for about two hours.

## VI. CONCLUSION AND RECOMMENDATION

This work has successfully demonstrated how energy from the sun and other electronic components such as diode, resistors, and capacitor can be used to actualize a fascinating output. Since, in this part of the world suffer epileptic power supply, maintenance personnel and quality operators of computerized genotype machine that can solve this problems by employing a simple circuit, low voltage power supply and easy to operate mechanism. Therefore this solar powered electrophoretic is ideal for third world countries like ours.

Finally, this solar powered electrophoretic has variable resistors that can enable control voltage in cases of eliminating incessant breakdown of our electrophoresis machine since its circuits is simple and check can be serviced by any person with little electronic knowledge.

Based on the findings and conclusion, it is believed that the Solar Powered/rechargeable Electrophoretic Machine would help alleviate the problems faced by the hospitals in testing of genotype of different individuals. The following recommendations are hereby made.

First and foremost, it would be the best thing for hospitals to introduce solar powered electrophoresis machine that can be automated, that is, the machine that contains a thermostat for auto-regulation.

Secondly, hospitals should introduce this type of machine that has an alarm for job completion indication.

  

## VII. ACKNOWLEDGMENT

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## VIII ACKNOWLEDGMENT

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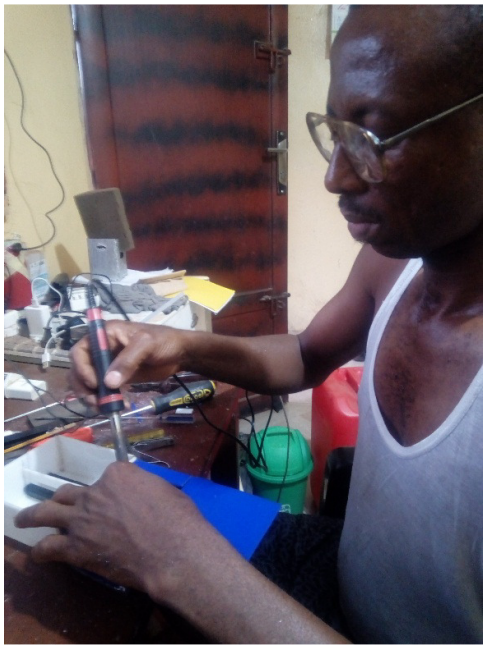
## PICTURES



OkorieAlphonsus doing soldering on the Circuit Board

OkorieAlphonsus coupling the Electrophoretic Maching