DESIGN AND CONSTRUCTION OF SOLAR LIGHTING SYSTEM WITH P. H. C. N. AS AN ALTERNATIVE POWER SOURCE

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DEDICATION

This project is hereby dedicated to Almighty Allah and the entire members of Oyerinde Family.

DECLARATION

I, OYERINDE TIRIMISIYU OYETUNDE, declare that this work was done by me and has never been presented elsewhere for the award of a degree. I hereby relinquish the copyright to the Federal University of Technology, Minna.

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ABSTRACT

This project work based on design and construction of a Solar Lighting System with P. H. C. N. as an alternative power source. It aimed at providing illumination in an area where P. H. C. N. supply is not existing or very erratic. The circuit was designed such that the battery 6v can be charging via solar panel and P. H. C. N. supply. It was also designed in such a way that when the battery is charging, the bulb connected to the output will glow.

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CHAPTER ONE

1.0 INTRODUCTION

Solar Power Technology

The technology used to create this power is based on a substance that is able to convert the suns energy to electricity. When sunlight heats specific materials, must notably silicon, it makes the electron inside jump around. Once those electrons are following in the same direction, they create a flow of energy, commonly known as electricity.

Solar power first came on the commercial scene in the United State on large scale in the 1970s when the price of oil sky rocketed at least, according to the price of the day. The first type of solar technology to gain popularity was mechanical solar power.

In early models, a solar reflector would heat water, creating steam, which would then power a small steam engine of the day.

Engineers discovered that by using curved or parabolic dishes they could focus the sun's light more intensely, create more steam, and therefore make the engine work faster. More modern examples employ large "dishes" of multiple mirrors which track the sun throughout the day. In the centre of the dish is a receiver, which transmits the heat to a hydro – filled engine.

When the hydrogen is heated it expands and drives piston which in turn drives a generator and produces electricity

1.1 Aims and Objectives

The aims and objectives of this project is to design and construct "Solar Lighting

System" with " P. H. C. N." as an alternative power source in order to touch the lives of people residing in a remote areas where P. H. C. N. Supply is not in existence or very erratic.

1.2 Motivation

Because of it cleanest, greenest source of power on the planet, solar power is known to be one of the best. Its ultimate renewable every morning the sun rises because the sun's energy will be converted to electrical energy through the solar array which could be use at home.

For centuries, solar energy has been used in low technology applications like drying clothes and food. Today solar cells are commonly used to power calculators, wrist watches and light.

Solar energy is free and it produces no pollution or waste. Among the modern applications it is being installed on houses and commercial buildings. The advantage of the installation is that it provides shade for the building whereby reducing the costs of cooling and also provides energy to serve everything in the building.

There is really no better source of energy in remote locations than solar. Infact, it helps power the space shuttle while it orbits earth.

Solar power is silent, produces no emissions and does not drain the planet's resources. The only thing it really takes is space which is not much of an issue.

1.3 Methodology

With reference to the block diagram in figure 1.1, this project involved three sources, the solar source, the P.H.C.N source and the battery source. The P.H.C.N source serves as an alternative source to solar source. For either of the source, the output voltage to the control unit is 12V

The 12V was connected in parallel to both switching and regulating state. The voltage connected to the switching state was used to energize the relay while the one across the regulating state regulates to suit the charging unit. After a successful changing of the 6V, 4.5 AH maintenance free lead battery, the output powered a 3W bulb.

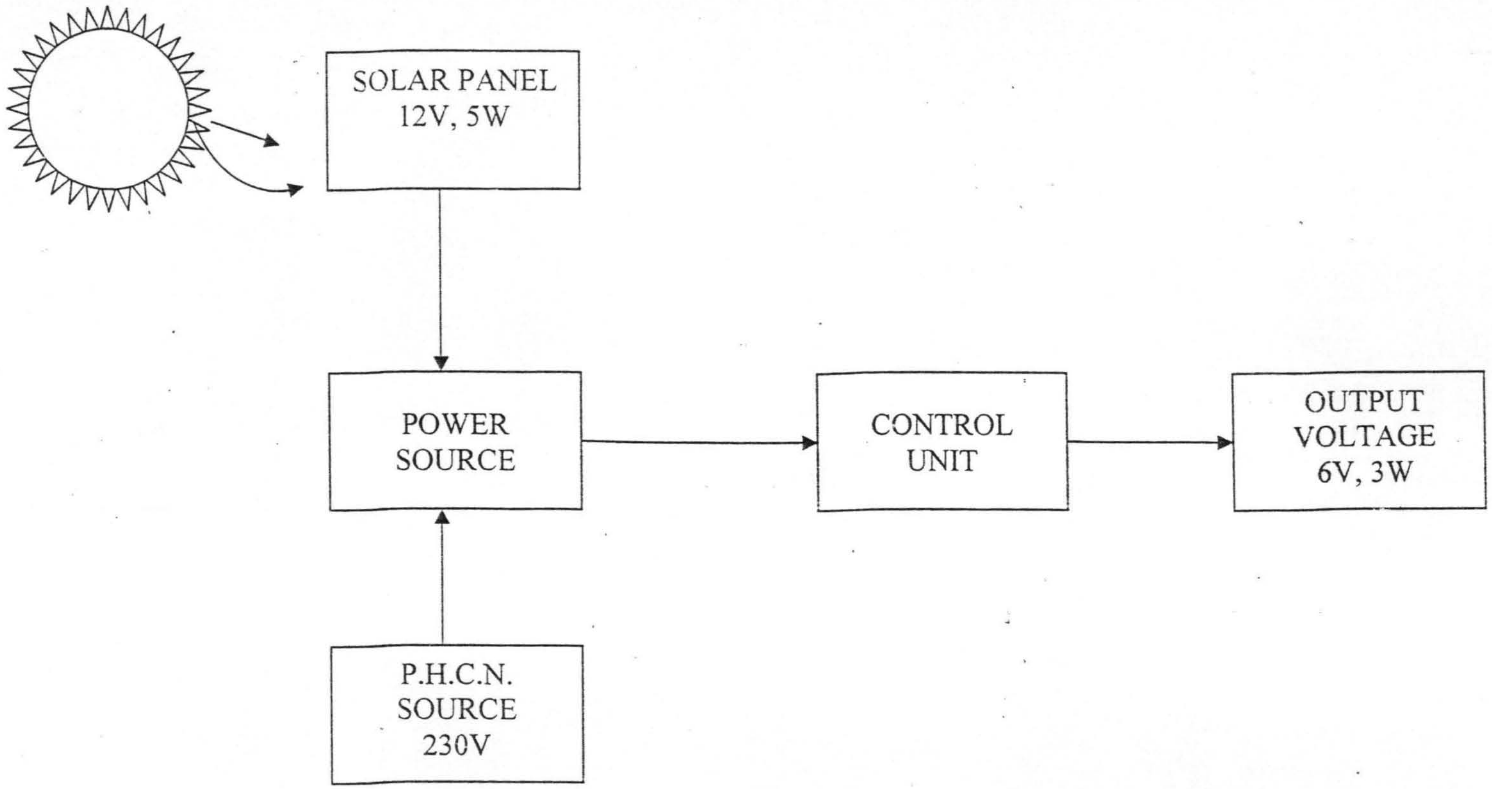

FIG. 1.1   BLOCK DIAGRAM

1.3 Scope of the Project

The project focuses on the construction of a lighting device that is totally dependent on both light and hydro for its power. The device is not meant to be an infinite source of illumination, as it runs on battery power and can only work when the battery has been sufficiently charged. It was designed for domestic use in rural areas that do not have any form of electricity.

CHAPTER TWO

LITERATURE REVIEW

2.0 The Sun

The sun (latin:sol) is the star at the centre of the solar system. The earth and other matter (including other planets, asteroids, meteoroids, comments and dust) orbit the sun. It is the largest mass in our solar system. The sun is composed of hydrogen (about 74% of its mass, 92% of its volume), helium (about 25% of mass, 7% of volume) and trace quantities of other elements. It is about 150million Km from the earth. The sun's surface is called the ***"Photosphere"***. The temperature at the core, or very middle, of the sun, is about 27 million^{0}fahreheit, approximately 15million degrees Celsius. The sun losses approximately 4million tons every second; this is the amount of hydrogen gas that the sun turns into energy. Energy from the sun, in the form sunlight, support almost all life on earth via photosynthesis, and drives the Earth's climate and weather.

2.1 Solar Energy

Humanity's moat fundamental understanding of the sun is as the luminous disk in the sky, whose presence above the horizon creates day and whose absence causes night. In many prehistoric and ancient cultures, the sun was thought to be a solar deity or other supernatural phenomenon, and worship of the sun was central to civilizations such as Inea of South America and the Azetees of what is now mexico.

Solar technology has its history from the 7th century BC, when the sun's heat was concentrated with mirrors and glasses for lighting fires. It was not until the early nineties that the research work into solar power generation began. The sun was basically looked upon as a continues source of energy (10). One of the first applications of the earth's solar resources was carried out by the ancient Egyptians, who used the sun for the mummification of their kings. In this case, the bodies of their kings were embalmed, wrapped in linen and placed in pyramids. The pyramids were built in such a way to optimal receive sunlight from the sun. Another early application of solar energy can be found in the drying of pottery items and meat during the early development of the Homo sapien man. Solar energy was then mainly used for its drying and preservatives qualities. Even in the present day Nigeria, most Northerner still employ the sun's drying ability during the preparation of a delicacy called "Kilishi". Here, the raw beef is simply spiced and left under the sun to dry.

2.2 Photovoltaic Cells

All these were before the advent of photovoltaic cells. The term photovoltaic come from the Greek: Phos meaning "light", and "voltaic" meaning electrical, from the name of the Italian physicist Volta, after whom the measurement unit volts are named. The term "photo – voltaic" has been in use in English since 1849. A solar cell or photovoltaic cell is a device that converts light energy into electric energy. Some times the term solar cell is reserved for advances intended specifically to capture energy from sunlight, while the term photo voltaic cell is used when the light source is unspecified.

The first applications of cells were in the construction of yard and street lamps in the early nineties. These lamps were not very popular because they were expensive to build, and the technological know-how was still at its beginning. However, within the last twenty- five years, solar technology has greatly improved. Photovoltaic are now being combined into solar panels for maximum efficiency [12]. The power output of a solar array is given in Watts or Kilowatts. In order to calculate the typical energy needs of the application a measurement in watt –hours, Kilowatt –hours or Kilowatt- hours per day is often used.

2.3 Diode

Although the crystal diode was popularized before the thermionic diode, thermionic and solid state diodes were developed in parallel. The principle of operation of thermionic diodes was discovered by Frederich Guthrie in 1873. [1]. The principle of operation crystal diodes was discovered in 1874 by the German scientist, Karl Ferdinand Braun. [2]. At the time of their invention, such devices were known as rectifiers. In 1919, William Henry Eccies connect the term diode from Greek roots: di means "two" and ode (from odos) means "path".

2.4 Transformer

The transformer principle was demonstrated in 1831 by Micheal Faraday, although he used it only to demonstrate the principle of electromagnetic induction and did not foresee its practical uses. The first widely used transformer was the induction coil, invented by Irish Clergy man, Nicholars callan in1836. [49] He was one of the first to understand the principle that the more turns a transformer winding has, the larger emf. it produces. Induction coils evolved from the supply being measured and to have a precise voltages ratio to accurately step down high voltages so that metering and protective relay equipment can be operated at lower potential [29]

2.5 A rectifier is a device that conducts electricity in one direction but not in other.

In 1874, brown noticed that this was a natural effect in some crystals, particularly galena. Crystal rectifier gave growth to crystal radios and eventually to the development of the transistor.

1850 - 1918, Braun discovered the rectifier when probing a crystal of galena in 1874. He went on to develop the first cathode ray oscilloscope in 1897 and was awarded a Nobel Prize in 1909 for his work on wireless telegraphy.

The crystal rectifier was instrumental in the development of crystal radio and the cathode ray oscilloscope led to the cathode ray tubes being used as monitors for rader and eventually television.

2.6 LED (Light Emitting Diode)

The first known report of a light emitting solid state diode was made in 1907 by the British experiment H.J round of marconis labs [6}. Russian Oleg vilandi Mirovich Losev independently created the first LED in the mid 1920s; his research, though distributed in Russian, German and British scientific journals was ignored, [7] [8] and no practical use was made of the discovery for several decades. Robbin Braustein of the Radio cooperation of America reported an infrared emission from gallum arsenide (GaAs) and other semi-conductor alloys in 1955 [9]. Braunstein observed infrared emission generated by simple diode structures using Gasb, GaAS, InP and Gest alloys at room temperature and at 77K. In 1961, experimenters Bob Blard and Gray Pittman working at Texas instruments, [10] found that gallium arsenide gave off infrared radiation when electric current was applied. Blard and pitman were able to establish the priority of their work and received the patent for the infrared light-emitting diode.

2.7 Relay

A relay is an electrical switch that opens and closes under the control of another electrical circuit. In the original form, the switch is operated by an electromagnetic to open or close or many sets if contact. It was invented by Joseph Henry in 1835. Because a relay is able to control an output circuit of higher power than the input circuit, it can be considered to be, in a broad sense, a form of an electrical amplifier

2.7.1 Types of Relay

1. Latching relay
2. Road relay
3. Mercury- wetted relay
4. Machine tool relay
5. Polarized relay
6. Contactor relay
7. Solid state contactor relay
8. Bluchholz relay
9. Forced- guided contacts relay
10. Solid -state relay
11. Overload protection relay

2.7.1.1 Latching Relay

A latching relay has two relaxed states (bi-stables). These are also called 'keep' or 'stay' relays. When the current is switched off, the relays remain in its last state. This is achieved with a solenoid operating a ratchet and cam mechanism, or by having two opposing coils with an over-center spring or permanent magnet to hold the armature and contacts in position while the coil is relaxed, or with a remnant core. In the ratched and cam example, the first pulse to the coil turns the relay on and the second pulse turns it off. In the two coils example a pulse to one coil turns the relay on and a pulse to the opposite coil turns the relay off. This type of relay has the advantage that it consumes power only for an instant, while it is being switched, and it retains its last setting across a power outage.

2.7.1.2 Reed Relay

A reed relay has a set of contacts inside a vacuum or inert gas filled glass tube, which protects the contacts against atmospheric corrosion. The contacts are closed by a magnetic field generated when current passes through a coil around the glass tube. Reed relays are capable of faster switching speeds than larger types of relays, but have low switch current and voltage ratings.

2.7.1.3 Mercury-Wetted Relay

A mercury-wetted reed relay is a form of reed relay in which the contacts are wetted with mercury. Such relays are used to switch low-voltage signals (one volt or less) because of its low contact resistance or for high-speed counting and timing applications where the mercury eliminates contact bounce. Mercury-wetted relays are positionsensitive and must be mounted vertically to work properly. Because of the toxicity and expense of liquid mercury, these relays are rarely specified for new equipments

2.7.1.4 Polarized Relay

A polarized relay placed the armature between the poles of a permanent to increase sensitivity. Polarized relays were used in middle 20^{th} century telephone exchanges to detect faint pulses and correct telegraphic distortion. The poles were on screws, so a technician could first adjust them for maximum sensitivity and then apply a bias spring to set the critical current that would operate the relay.

2.7.1.5 Machine Tool Relay

A machine tool relay is a type standardized for industrial control machine tools, transfer machines, and other sequential control. They are characterized by a large number of contacts (sometimes extendable in the field) which are easily converted from normally-open to normally-closed status, easily replaceable coils, and a form factor that allows compactly installing many relays in a control panel. Although such relays once were the backbone of automation in such industries as automobile assembly, the Programmable Logic Controller (PLC) mostly displaced the machine tool relay from sequential control applications.

2.7.1.6 Contractor Relay

A contractor is a very heavy-duty relay used for switching electric motors and lighting loads. With high current, the contacts are made with pure silver. The unavoidable arcing causes the contacts to oxidize and silver oxide is still a good conductor. Such devices are often used for motor starters. A motor starter is a contractor with overload protection devices attached. The overload sensing device are a form of heat operated relay where a coil heats a bimetal strips, or where a solder pot melts, releasing a spring to operate auxiliary contacts. These auxiliary contacts are in series with the coil. If the overload senses excess current in the load, the coil is de-energized. Contractor relays can be extremely loud to operate, making them unfit for use where noise is a chief concern.

2.7.1.7 Solid State Contractor

A solid state contactors is a very heavy duty solid state relay, including the necessary heat sink, used for switching electric heaters, small electric motors and lighting loads, where frequent on/off cycles are required. There are no moving parts to wear out and there is no contacts bounce due to vibration. They are activated by AC control signals or DC control signals or DC signal from Programmable Logic Controller (PLCS), PCS, Transistors-transistor logic (TTL) sources, or other microprocessor controls.

2.7.1.8 Buchholz Relay

A Buchholz relay is a safety device sensing the accumulation of gas in large oil filled transformer, which will alarm on slow accumulation gas or shut down the transformer if gas is produced rapidly in the transformer oil.

2.7.1.9 Forced Guided Contacts Relay

A force-guided contacts relay was relay contacts that are mechanically linked together, so that when relay coil is energized or de-energized, all of the linked contacts move together. If one set of contacts in the relay become immobilized, no other contact of the same relay will be able to move. The function of force-guided contact is to enable the safety circuit to check the status of the relay. Forced guided contacts are also known as "positive guided contact" captive; "locked contacts" or "safety relays".

2.7.1.10 Solid - State Relay

A solid-state relay (SSR) is a solid-state electronic component that provides a similar function to an electrochemical relay but does not have any moving components, increasing long-term reliability. With early SSR's, the trade off came from the fact that every transistor has a small voltage drop across it. This collective voltage drop limited the amount of a given SSR could handle. As transistors improved, higher current SSR's, able to handle 100 to 1,200 amps, have become commercially available. Compared to electromagnetic relays, they may be falsely triggered by transients.

2.7.1.11 Overload Protection Relay

One type of electric motor overload protection relay is operated heating elements in series with the electric motor. The heat generated by the motor current operates a bi-metal strip or melts solder, releasing a spring to operate contacts. Where the overload relay is exposed to the same environment as the motor, a useful though crude compensation for motor ambient temperature is provided.

CHAPTER THREE

3.1 DESIGN AND IMPLEMENTATION

This chapter contains the actual construction of a solar lighting system which have P. H. C. N. as an alternative power source. It also describe all the necessary test carried out during the implementation of the circuit.

3.1.1 Components Analysis

i. **Power Supply System:** Electronics power supply provides the energy for the circuit to work.

There are three types of power supply in the circuit namely:

i) P. H. C. N. Supply (230V)

ii) Solar Panel Supply (12V)

iii) Direct current (DC) Battery (6v, 4.5AH).

P. H. C. N. Supply (230V): This is an output of P. H. C. N. step-down transformer. It was gotten by connecting a phase and neutral.

Solar Panel: Solar panels convert energy in the form of light from the sun into electrical energy. Only between 2 and 22% of the energy that falls on a panel is converted to usable electrical energy. The remaining energy is transformed into heat. Solar panel consist of a number of cells, bench work together to create a high voltage to give off sufficient energy. Energy from the sunlight beats down on the solar panel crystals within these cells, knocking some electrons loose. This action creates electricity. A solar panel is made up of 30 – 36 connecting cells, produces 12 to 16V.

In this project, the output of the solar panel used was 12V, 5W.

Transformer: A transformer is a static piece of apparatus by means of which electrical power is one circuit is transformed into electrical power in another circuit. In this project, a 12V step-down transformer was used to step-down the P. H. C. N. input voltage (230V) to 12V.

Rectification: This is a circuit which employ one or more diodes to convert AC voltages into pulsating dc voltage. However, there are many circuits that can be used for rectification. These includes:

i) Single-phase half-wave rectifier circuit

ii) Single-phase full-wave rectifier circuit

iii) Full-wave bridge rectifier circuit.

But the type employed in this project was a full-wave bridge rectifier circuit and the value of the current rating is 1A.

Filtering: In this project, the value of the capacitor used was 2200μF, 35V. it was connected in parallel with a 12V relay coil in order to increase the response time of the relay. It was also used to filter the rectified output if the battery is charged through the power. A capacitor's capacity to store energy is called its capacitance, C, which is measured in Farads. It can be any value from PF to MF. The current through the capacitor is equal to C multiplied by the rte of change in voltage across the capacitor, that is (mathematically),

$$I = C\frac{dV}{dt}$$

Where I is the current

$^{dv}/_{dt}$ is the rate of change of voltage with respect to time C is the capacitance.

Relay: A relay is an electrical switch that opens and closes under the control of another electrical circuit. In the original form, the switch is operated by an electromagnet to open or close one or many sets or contacts. In this project, the value of the relay used was 12V, 200Ω.

Voltage Regulation: Voltage regulation is one of the most important regulated power supply components. It is the measure of a supply's ability to maintain a constant output voltage. In this project, IC 7808 and a diode was used to regulate the supply.

Diode: In ideal diode is a two element device which has the circuit symbol and volt-ampere characteristics below. The current in the device is in one direction only so that the ideal diode is a unilateral circuit element. In the symbol below, when V. P. is equal to zero, I_D can have any positive value and when I_D is equal to zero, V_D can have any negative value.

Limiting Resistor: The purpose of the resistor is to create specified values of current and voltages in a circuit. They come in a variety of sizes. Depending on the power they can safely dissipate. A resistor's resistance, R, is measured in ohms (Ω), colour coded stripes on a real-world resistor specify its and tolerance. The values of resistor used in this project are 1KΩ and 100Ω.

Light Emitting Diode (LED): This is a diode which emits light in a variety of colours when conducting. LEDs are constructed of gallium arsenide or gallium arsenide phosphide. While efficiency can be obtained when conducting as little as 2 milliampere of current, the usual design goal is in the vicinity of 10mA. During conduction, there is a voltage drop across the diode of about 2 volts..

In this project, the value of the relay used was 12V, 200 Ω. The capacitor was used to increase the response time of the relay, therefore switching occurs moments after the voltage across the relay falls below 12V, that is, the relay will energize when it senses voltage below 12V and de-energizes when the voltage is off.

3.1.2 CIRCUIT OPERATION

Solar cells generate direct current (D.C.), so it was ensure that DPDT switch S_1 was towards the solar panel side. The DC voltage from the solar panel was used to charge the battery and control the relay. The capacitor C_1 was connected in parallel with a 12V relay coil remained charged whenever the supply is on until the relay is activated. Capacitor C_1 was used to increase the response time of the relay, so switching occurs moments after the voltage across it falls below 12V.

The higher the value of the capacitor, the more the delay in switching. The switching time is to be properly adjusted because the charging would practically stop in the early evening while we want the light to be 'on' during late evening. But in a situation whereby there is PHCN supply, the circuit can be charging the battery and at the same time power the output bulb.

During the day time, relay RL1, energizes, provided DPDT switch S_1 is towards the solar panel side. Due to energization of relay RL1, the positive terminal of the battery will be connected to the output of regulator IC 7808 (a 3 terminal, 1A, 8V regulator) via diode D_1 and normally open (N/O) contact of relay RL_1. Here, a 6V, 4.5A maintenance-free, lead-acid re-chargeable battery was used. It requires a constant voltage of approximately 7.3 volts for its proper charging.

Even though the output of the solar panel keeps varying with the light intensity, IC 7808 (IC_1) was used to give a constant output of 8V. Diode D_1 causes a drop of 0.7V, so approximately 7.3V will be gotten to charge the battery.

LED1 indicates that the circuit is working and the battery is in the charging mode.

At night, there will be no generation of electricity except P.H.C.N. supply is available. If there is no P. H. C. N. supply, the relay will not energize and charging will not take place. Then the energy stored in the battery can then be used to light up the lamp. A 3W lamp glows continuously for around 6 hours if the battery is fully charged. But if the P.H.C.N. supply is available, the battery will be charging and the output bulb will glow.

In case the battery is connected in reverse polarity while charging, IC 7808 will get damaged. The circuit indicate this damage by lighting up LED2 which was connected in reverse with resistor R_2.

Provision was also made for estimating the voltage in the battery and it was done by connecting ten IN4007 diodes (D2 through D_{11}) in forward bias with the battery. The output was taken by LED3 across diodes D2, D3, D4 and D5; which is equal to 2.8V when the battery is fully charged. LED3 lights up at 2.5 volts or above. Here it glows with voltage drop across the four diodes, which indicates that the battery is charged. If the battery voltage falls due to prolonged operation, LED3 will no longer glows as the drop across D2, D3, D4 and D5 is not enough to light it up. It indicates that the battery is weak.

CIRCUIT DIAGRAM

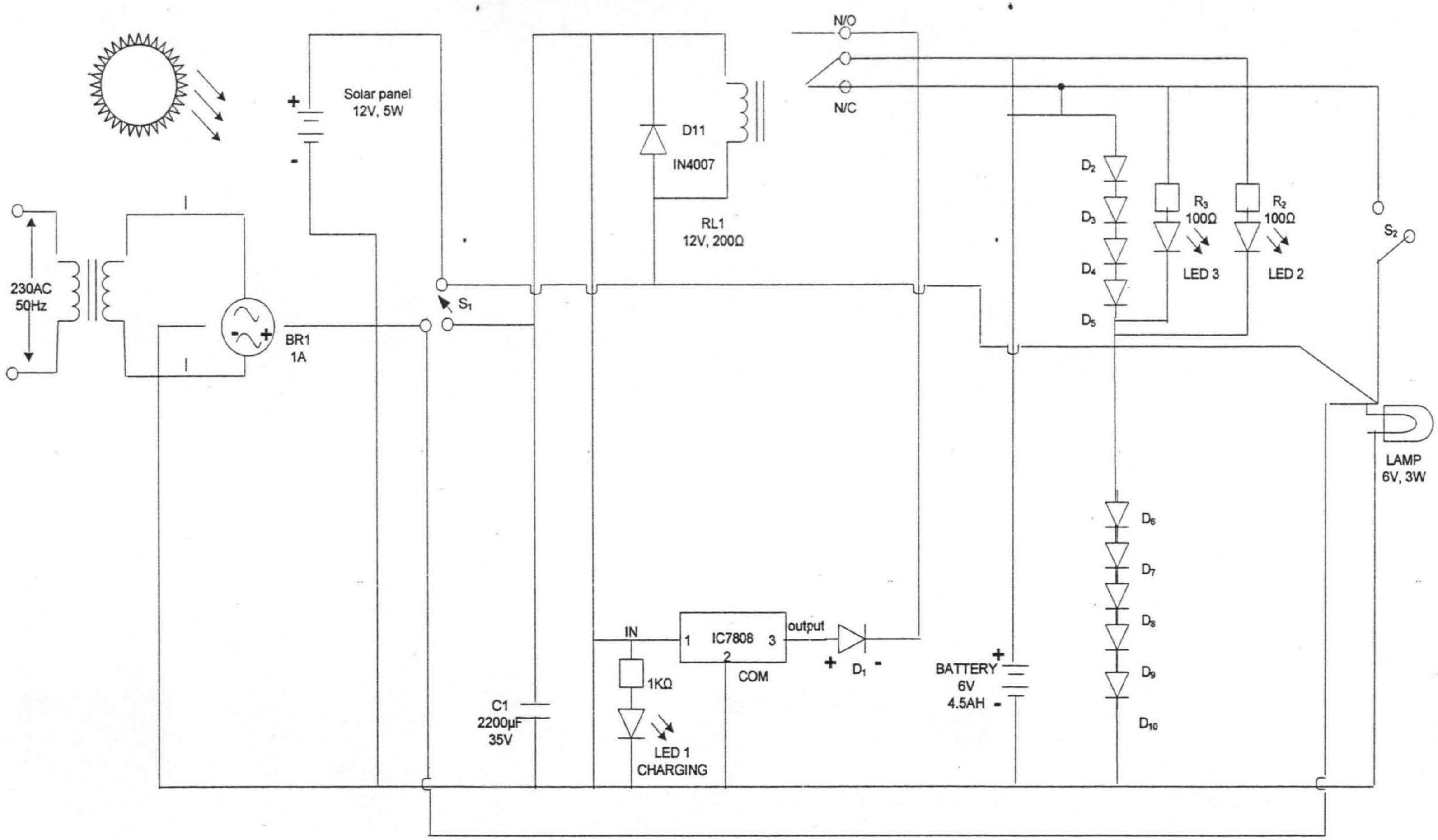

FIG. 3.1 DUAL POWER SYSTEM

CHAPTER FOUR

CONSTRUCTION, TESTING AND CASING

4.1 CONSTRUCTION

The construction was done in a module – to – module pattern. The power supply was the first stage to be constructed. It was coupled on the breadboard, and later transferred to the veroboard.

The components were soldered on the vero board using lead and 60 watts soldering iron. This provides electrical continuity and firmness on the board. Jumper-wire were used to connect various points together and also to bridge the connection between the components making up sections. The stages were tested to ensure that there were no deviation from the desired specification.

4.2 TESTING AND RESULT

In carrying out the test for basic components of this project, the main instrument used are ohmmeter and multimeter. Testing was carried out on the IC 7808, the output and input power supply to each stages and the output of each stage.

Ohmeter was used to measure the resistance of both 1KΩ and 100Ω of the limiting resistor. For the 1KΩ when measured, the value gotten was 999.8Ω while for the 100Ω when measured, 99.7Ω was gotten. The output power of the rectifier stage was measured using multimeter. This was found to be 11.5 – 12V DC. The voltage at the input of the voltage regulator was 11.8V and the output was 8V. At the output of IC 7808, Diode D_1 caused a drop of 0.7V while the voltage balance of 7.3V was measured which was the voltage used in charging the battery.

4.3 CONSTRUCTION OF CASING

For casing was made up of dark blue plastic. The shape of the casing was rectangular box. The size was chosen such that it can contain the transformer and the veroboard which contain all the components.

4.4 FINAL COUPLING AND ASSEMBLING

The final coupling involves the transferring of the transformer and the verobaord into the casing. The transformer was strongly mounted on the seat made for it using screw. The veroboard was also screwed to its seat in the casing. All other connections were made such as connection to switches and power indicator LEDs.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The design and construction of the solar lighting system with P. H. C. N. as an alternative power source is a very suitable project most especially in Nigeria were the P. H. C. N. supply is not constant, since solar panel generate its energy from sunlight which require no noise and no environmental pollution, it is best alternative to the incessant black out in this country. Apart from illumination, the area in which solar system is applicable are:

1. Equipment
   a. Water purification
   b. Refrigerators
   c. Portable pumping station
2. Generators
   a. Photo voltaic generators
   b. small generators
   c. small battery chargers
   d. UPS/ backup power
3. Communications
   a. Call boxes
   b. portable AM/FM radios
   c. Radio cellular phones

d. Radio base stations

e. portable hand-held radios

4. Health care system

a. Lighting in rural clinics

b. Vaccine refrigerations

c. Sterilizers

d. Blood storage refrigerators

5. Lighting

a. Street lighting

b. Security lighting

c. Personnel lights/residential lighting

d. Billboards and highway signs.

6. Transportation

a. Highway chargeable message sign

b. Road markers

c. Hazard and warning lights.

5.2 Recommendation

Since the maximum output of this project is 3W, I hereby recommend that the power rating should be increased when illumination of large area is required.

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