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DESIGN AND INSTALLATION OF 3.5KVA SOLAR POWERED SYSTEM

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Abstract

Solar energy less significant threat to human health, as well as the greenhouse effect and high maintenance costs of power generation systems. The study focused on designing and implementing a low-cost solar power inverter system with DC batteries that could supply 230V AC when completed. The design's operating principle is that when the sun shines on the photovoltaic cells, the cells convert the solar energy into a DC volt, which is then utilized to charge the battery via the charger controller, which regulates the charge. The inverter is powered by a battery that is attached to it. The inverter converts DC electricity from the battery to AC voltage, which may then be used to power appliances in the various departments when the installation is completed. The output voltage is shown on an LCD as an extra function. Finally, the designed system circuit was thoroughly tested and found to operate admirably. It will be able to accomplish the above functions properly at the end of this project. The performance of the 3.5KVA solar-powered system has been satisfactory, and it is performing as expected.

Keywords:

Sun, Radiation, Photovoltaic cell, and Solar power.

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1.0 Introduction:

Power can be generated from the variety of ways, including the use of water, wind, solar or steam energy to drive the turbine, and, more recently, the use of gas. (Dubey and Kasarabada, 1993). In developing countries such as Nigeria, insufficient power supply is one of the major challenge due to ever growing population. This is usually an imbalance between the quantity of power supplied and the quantity of power needed for domestic and industrial use. (Okeke, and Ehikhamenle 2017).
The utilization of solar powered system as a method for supply of power is extremely invaluable as vitality from the sun is plentifully and too much accessible.

The solar source of energy helps the environment from contaminants, commotion, and hazardous discharges thanks to power (Horowitz and Winifred, 1989). It's also more profitable because there are less land restrictions. Despite the fact that this period technology is incredibly expensive, it is an extremely productive and reliable power supply method. As a result, the design and implementation of a 3.5KVA solar power system for domestic has becomes important.

2.0 Literature Review

People have been attempting to convert d.c. power to a.c. power since the late 1800s, and until the mid-20th century using rotary converters. (Owen, 1996).
Alexandre-Edmond Becquerel (1839) discovered that some materials can generate an electrical charge when exposed to light. Even though the first solar panels were too inefficient to power even simple electric equipment, they were utilized as a light meter.

William G and Richard E. (1876) published "The action of light on selenium," outlining the method they conducted to duplicate Smith's findings. (Mansoor and Calwell, 2010).

Charles Fritts (1881) created the first commercial solar panel, which was reported by Fritts as "continuous, constant and of considerable force not only by exposure to sunlight but also to dim, diffused daylight." However, these solar panels were very inefficient, especially compared to coal-fired power plants. (Mansoor and Calwell, 2010).

Russell O. (1939) created the solar cell design that is used in many modern solar panels. This design was first used by Bell Labs to create the first commercially viable silicon solar cell. (Mansoor and Calwell, 2010).

Mohamed M. Atalla (1957) developed the process of silicon surface passivation by thermal oxidation at Bell Labs. The surface passivation process has since been critical to solar cell efficiency (Love, 2013).

3.0 System Component Analysis;

The following components are needed in the installation of a solar power system

i. Charge controller: The power from the solar array that goes into the battery bank is managed by a solar charge controller. It prevents the deep cycle batteries from being overcharged during the day and prevents power from flowing backwards to the solar panels overnight, draining the batteries. Although some charge controllers include extra features such as lighting and load management, their primary function is to manage electricity. PWM and MPPT are two alternative technologies for solar charge controllers. They are significantly different in terms of how they operate in a system. Although an MPPT charge controller is more expensive than a PWM charge controller, the extra cost is typically justified (Paice, 1996).

Figure 1.0 Solar Charge Controller

ii. Photovoltaic Cell (solar panel): Solar energy can be converted directly into electricity by means of a panel (or module) consisting of solar cells, which are semiconductor photoelectric devices. Solar cells are today made in two board categories of the crystalline group and the amorphous group (Fagbenle R., 2001).

Mono-crystalline solar panels are the most efficient (rated 15- 20%) and expensive PV panels are made with mono-crystalline cells. These cells use very pure silicon and involve a complicated crystal growth process.

Poly or multi-crystalline solar panels are made with poly-crystalline cells, are little less expensive and slightly less efficient than mono-crystalline cells because the cells are not grown in single crystals but in large block of many crystals. Like Mono-crystalline cells they are also then sliced into wafers to produce the individual cells that make up the solar panel.

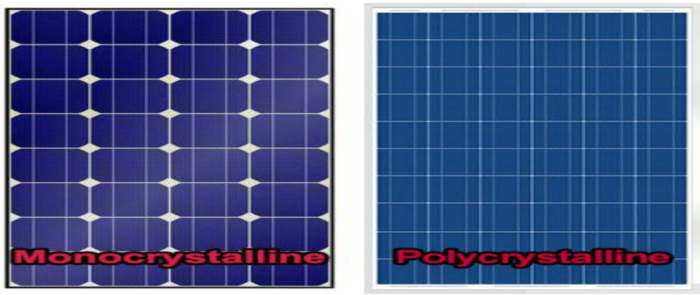

Figure 2.0. Solar Panels **(Fagbenle R., 2001).**

iii. **Battery:** A battery is an electrical apparatus with two dissimilar electrodes immersed in a liquid known as electrolyte inside a container which dissolves to produce a d.c electrical energy (Mansoor and Calwell, 2010). This process entails a combination of several cells or compounds that converts chemical energy into electrical energy which is used as a voltage source for most portable electrical and electronics equipment such as calculators, transistor radios, wireless microphones, flashlights and many other d.c. battery operated devices (Singh, 2006). The two main types of cells are the primary (dry) cells and the secondary (wet) cells. The primary cells are not rechargeable when they are discharged while the secondary cells can be recharged when they discharge. The different types of battery include the lead-acid batteries, alkaline batteries, Nickel-iron or Edison batteries, silver-zinc batteries etc. (Mehta and Rohit, 2005)

Figure 3.0: Solar Battery

iv. **Solar Inverter :**An inverter helps converts dc power into an ac power. The inverter process can be achieved with the help of transistors, silicon control rectifiers (SCR), tunnel diodes etc. for low and medium power output transistorized inverters are suitable, but for higher power output SCR inverters are essential.

4.0: System Operation of a Solar System

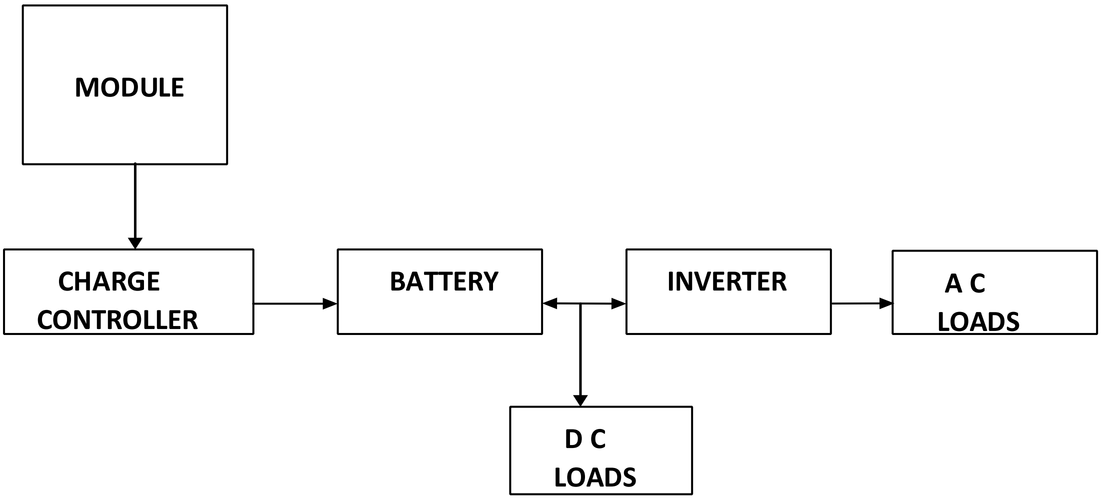

Figure 4.0. **Block Diagram of a Solar Power System**

The solar panel absorbs energy produced by the sun and converts it into electrical energy. It does this by absorbing the sun rays into the modules of the solar panel hence produced free electrical charge carriers in the conduction and valence bands. The electricity produced by the solar panel was then transferred to the charge controller as shown in figure 4.0. The charge controller regulates the rate at which electric current were drawn in and out of the battery. It turns off charge when the battery reaches the optimum charging point and turns it on when it goes below a certain level. It fully charges the battery without permitting overcharge.

The regulated voltage from the charge controller was then transferred to the solar battery. The batteries were the key component in this solar power system. It provided energy storage for the system.

The energy stored in the batteries was then used to power the load but it was first converted to AC voltage by the use of an inverter due to they were AC loads. The photovoltaic ally produced direct current was commuted periodically by controlled oscillatory system and feed to power electronic semiconductor switches such as transistors which were connected the power transformer. Here the voltage was stepped up to the desired ac voltage. The inverter could also charge the battery when there is public power supply.

5.0 Design Analysis and Calculation

i. Determination of Battery Bank Capacity

$$C_x = \frac{N_C \; X \; E_L}{DOD_{max} \; X \; V_{sys} \; X \; \eta_{out}} \qquad (1)$$

The minimum number of days of autonomy that should be considered for even the sunniest location on earth is 5 days. Due to cost, the most economical number of days of autonomy is $3\frac{1}{2}$. In this design the day of autonomy is taking as $3\frac{1}{2}$ days and the maximum allowable depth of discharge is taken as 75%.

Substituting into equation (1) when η_{out}= 0.90

$$C_x = \frac{3.5\ X\ 3332}{0.75\ X\ 24\ X\ 0.90} = 719.87\text{Ah}$$

Hence, the battery bank capacity is 719.87Ah that is about Four (4) batteries are needed for the design to be effective.

ii. Battery Specification and Required Number

The battery has a capacity of 200Ah and a nominal voltage of 12V.
Numbers of batteries required (N_{breq}) is given in the equation (2) below;

$$N_{breq} = \frac{C_x}{C_{selected}} \tag{2}$$

Where:

N_{breq} = Number of batteries required

$C_{selected}$= Selected capacity of battery

$$N_{breq} = \frac{719.87}{200} = \text{ 3.6 approximately 4 (four) batteries}$$

iii. Determination of the Inverter Size

Also to allow the system to expand, we multiply the sum of the two previous values by 1.25 as safety factor thus;

$$P_{total} = (P_{RS} + P_{LSC})X\ 1.1 \tag{3}$$

Ptotal = Inverter power rating (size)

PRS = Power of appliances running simultaneously

PLSC = Power of large surge current appliances

In this design, PLSC = 2.1.

Ptotal = (1.188 + 2.1) × 1.1

Ptotal = 3.498KW = approx. 3.5KW or 3.5 KVA
It implies that any cooper cable of cross sectional area of 12.33mm^2, 171.6A and resistivity 1.724 x $10^{-8}\Omega$m can be used for wiring between the battery and the inverter.

6.0 System Implementation,

i. Install the solar panels in an array and connect them in parallel to total the current.
ii. Install the charge controller on the wall, then connect the two (2) batteries (12 volts each) in series to bring the total voltage to 24 volts, and then connect to the

charge controller. The terminal port is then linked to the positive and negative terminal wires that originate from the panel.

iii. The positive and negative wires of the inverter are linked to the battery, paying attention to the polarity, while the main connection is plugged into the mains for electricity from BEDC, allowing the inverter to charge the battery using power sources other than the solar panel.

iv. The output from the inverter is then connected to the distribution box (DB) of the house (AC appliance).

7.0 System Testing

The solar panel was set placed under the sun at 45^o south, there the peak sun irradiation was on the panel surface and then at 39.5 volts was observed using a multimeter. While observing the voltage, the panel was slightly adjusted and the voltage varied at an angle away from the sun, the voltage depreciated.

The output from the solar panel was connected to the charge controller with respect to their polarities.

The inverter had three indicators. The first displayed if the system was connected to the mains or not, the second displayed if the inverter system was switched ON or OFF and the third was to display if the system was experiencing any fault or not.

The inverter also had an additional socket for plugging the inverter to mains to serves as another means to charge the batteries other than the solar system.

8.0 Result

The output from the solar panel was connected to the charge controller with respect to their polarities and when the output voltage was observed, it then read 46 volts which was right for charging 24 volts battery, since the four 12 volts batteries were connected in series. Also, there was an indicator on the charge controller that showed when the battery was full by showing green light and the other LED showed red when load was connected to the system.
Each battery read 12.8 volts each and then connected in series to give an output of 24 volts afterwards was connected to the inverter. The voltage was 25.7 volts DC because the solar and the charge controller were also connected but without load, then load was added to the inverter which gave an output of 220 volts and was left for about 30 minutes after then it was observed again and the voltage did not vary.

The output of the inverter was tested with the volt meter as it was plugged on the mains out, it read 28.8 volts which was basically because of the state of the charge level of the batteries. The batteries would normally self-discharge over time even when not used.

9.0 CONCLUSION

The solar system worked effectively with no operational cost and has less maintenance cost. When compared to a 3.5KVA petrol generator, it was costly at the point of installation. However, it was later seen to be cheap since the system needed no petrol to operate but sunlight which was nature's free gift. Therefore, there was no need to time or limit the hour of power supply of the up and down experiences from the mains supply.

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