Journal of science, education and technology
Volume 1 Number 1

Nov., 2007
ISSN 1596-9770

Design and Construction of Solar Energy -Operated Inverter Suitable For School Laboratory and Rural Development Activities in Niger State

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ABSTRACT The study aimed at constructing a solar energy-operated inverter capable of transforming 12 volts direct current (d.c) from a solar panel to 220 volts alternating current (a.c) as alternative source of electricity for school laboratory experiment and household use especially in rural areas. The constructed components of the inverter consist of a transformer, inverter switching circuit and pulse generation circuit. The transformer was made of 160 turns in the primary winding and 1400 turns in the secondary winding. Each winding has two tapping points. The inverter switching circuit was made up of two sets of power transistors, two on each side. The pulse generator was designed to serve as oscillator, made up of resistors, transistors, capacitors and diodes. A rectangular metal sheet cabinet was constructed to house the entire circuit. The study will be beneficial to electricity consumers especially rural dwellers who are in need of power supply for domestic use. Schools will also benefit from the study, as the inverter could be used for laboratory experiments.

INTRODUCTION

The global rapid technological developments and industrial growth of the past decades have created urgent and almost insatiable need for science and technology to be more functional (Olalekan, 1999). Presently, technology education in Nigeria is faced with problems which retard its development. One of these problems is the lack of facilities (Okoro, 1999). Nigeria is one of the countries in the world that is endowed with abundant natural resources and one of these resources is the sunshine which gives pure and inexhaustible solar energy (EIA, 2004). This type of energy is the most readily available source of power. If solar energy is properly utilized, it would reduce the problem of power supply.

Solar energy, according to Ljubisav and George (1995), is the energy from the sun which is one of the most promising of the renewable energy sources in view of its apparent limitless potentials. A major advantage of solar energy utilization is its pollution-free nature; unlike other sources of energy available to human race. Ljubisav and George went further to state that solar energy can be used to meet electricity requirements through solar photovoltaic cells.

Energy Information Administration (EIA) (2004), reported that photovoltaic energy is obtained by the conversion of sunlight into electricity through a photovoltaic cell, commonly called solar cell. The solar cell is the basic building block of a Pv system. Individual cells vary in size and one only produces 1 or 2 watts which is not enough power for most applications. To increase power output, cells are electrically connected into modules and modules connected to form array. The term array: refers to the entire generating plant, which is made up of two or more modules. Photovoltaic cells, like batteries, generate direct current (DC). For this type of current or power to operate on most electrical appliances, it must be converted to alternating current (AC) using inverters. A solar cell will supply 12 volts (DC) to a 12 volts 60Ah battery which will in turn supply 12 volt DC to the inverter for onward inversion to alternating current. The battery plays a supportive role in the system. It is used as a back-up so that in the night when the solar panel stops working, the battery takes over. The battery does not need any external charging as the solar cell generates power in the day time, it supplies 12V (DC) steadily to the battery so that the battery is always charged for work at all times.

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especially at night-time when the solar cell is not functioning (Ljubisav and George, 1995).

According to Energy Efficiency and Renewable Energy Clearing House (EREC) (2002), an inverter is an electronic device that changes the direct current (dc) electricity produced by photovoltaic cell into alternating current (ac), which powers most home appliances. Jaycar, (2000) explained that most inverters do their job by performing two main functions: First, they convert the incoming DC into AC, and they step up the resulting AC to mains voltage level using solid state devices and transformers. The goal of the designer is to have the inverter perform these functions as efficiently as possible, so that as much as possible the energy drawn from the solar panel is converted to alternating voltage (AC) for use in school laboratories and the rural communities.

The federal government has in the past few years put in efforts to ensure effective and efficient regular power supply in the country. Despite this effort, some rural areas still lack electricity supply (Ndudi, 2003). The cost of procuring electricity generating set and it's maintenance is high and unaffordable by these rural dwellers. Schools located in these rural areas do not have access to electricity supply to enable them perform laboratory experiments and to do other school activities.

The National policy on Education (2004) aims at transforming Nigeria from traditional society to a modern technological one. If this is to be realized, scientific and technical skills have to be inculcated into school children at the foundation level of their education. To achieve this goal, the need for the provision of regular power supply and other facilities can not be overlooked.

The purpose of this study is to design, construct and test a solar energy-operated inverter capable of transforming 12 volts direct current (dc) from solar panel to 220 volts alternating current (ac), having an output power of 500 watts as alternative source of electricity.

Experimental Design and Procedure

The solar energy-operated inverter (figure 1) comprises of four main parts viz: (i). The photovoltaic (Pv) modules (Array) (ii). The charge controller (iii). The battery (iv). The inverter

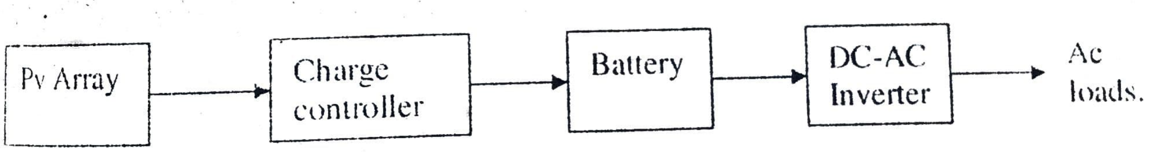

Fig 1 : Block Diagram of solar energy-operated inverter

The Photovoltaic Modules (Array)

The photovoltaic modules (Array) employed is made up of three modules connected to form an array. Each module is made up of 12 solar cells, and each cell is capable of producing electricity at a voltage of 0.5v. A total of 36 cells connected in series produce 18v, 55 watts.

Charge Controller

A charge controller which protects the battery from overcharging is connected between the photovoltaic array and the battery.

The Battery

The battery provides the dc input to the inverter. In this work, the battery used is

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the lead-acid type, car battery, with a current rating of 60Ah and voltage of 12 votts d.c.

The Inverter

The inverter unit was divided in the following subunits

(i). Pulse generating circuit (ii) Inverter switching circuit. (iii) Output power transformer.

Pulse Generator Circuit.

The pulse generator is designed to serve as an oscillator which is to operate at a desired frequency of say 50H2 to be able to drive the switching devices (Transistors). The circuit diagram of the pulse generator used as an oscillator is shown in figure 2 below.

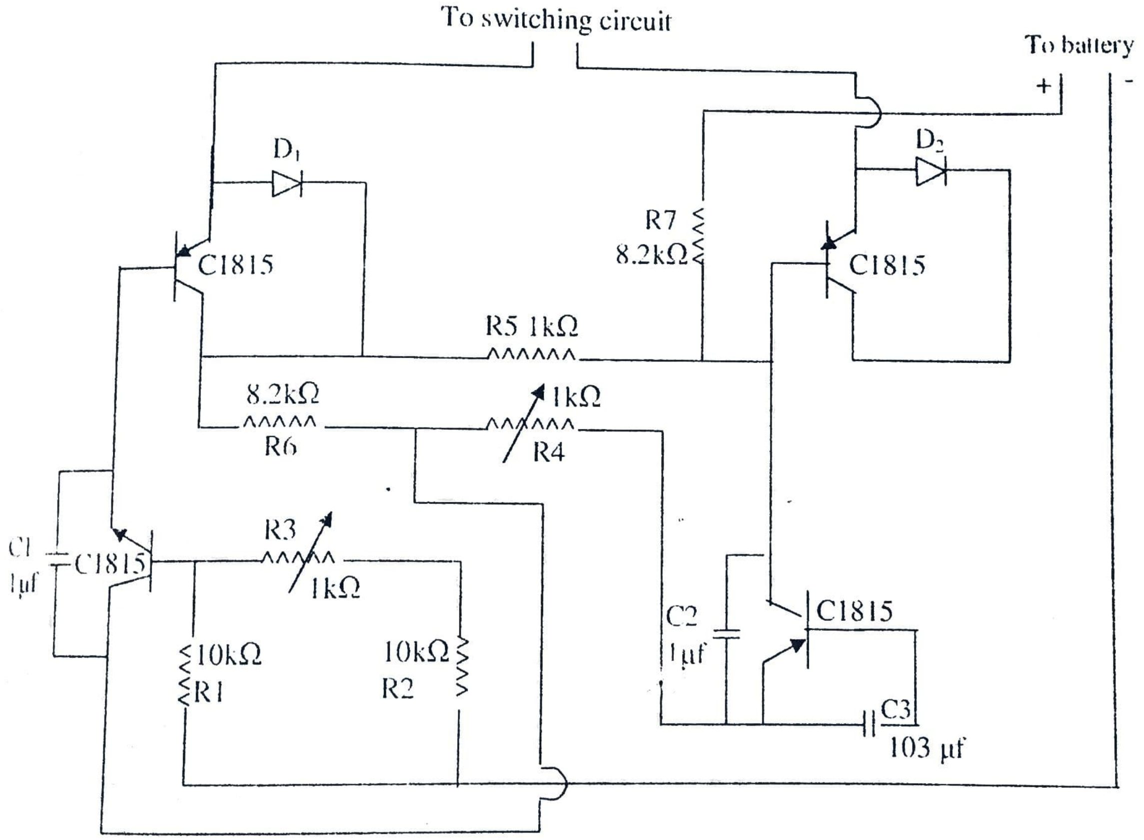

Fig 2 : Pulse Generator Circuit.

The Inverter Switching Circuit.

Four power transistor connected in parallel were used for the Inverter switching circuit (Figure 3). This allows for sharing of the load current and provides more efficient power handling. The transistors are connected directly to the power transformer to make up the power stage. Two transistors each are connected to each side of the transformer Primarily to share the heavy current. However, because they are essentially connected in parallel, these transistors could be considered as behaving in the same way as if a single transistor is used on each side.

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ISSN 1596-9770

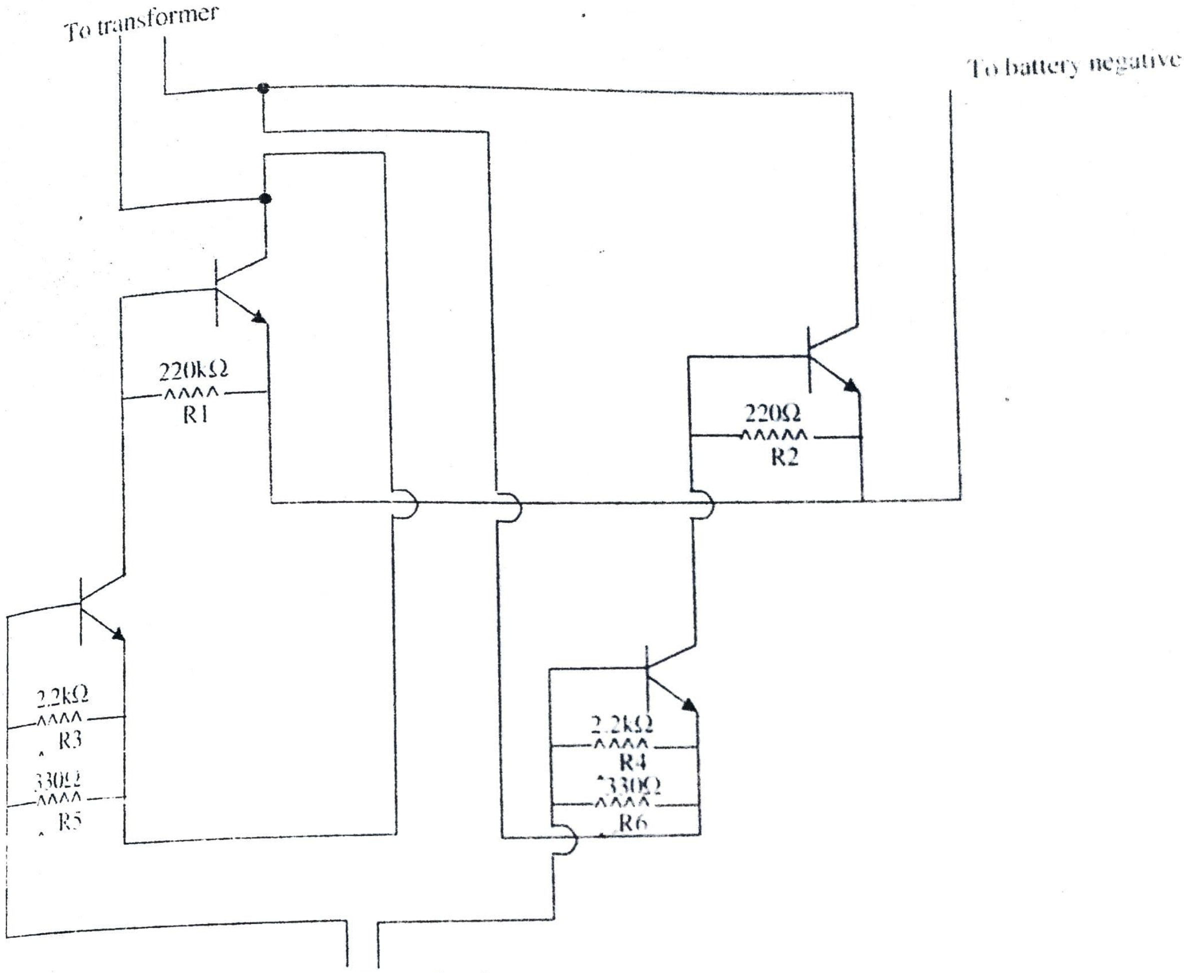

Fig 3: The Inverter Switching Circuit

The Output Power Transformer.

A step up transformer manually wound with primary turns of 160 centre tap and 1.400 tums in the secondary windings was used. The standard wire guage used for secondary and primary coils of the transformer are 26 and 14. The complete inverter circuit is shown in Figure 4 below.

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ISSN 1596-9770

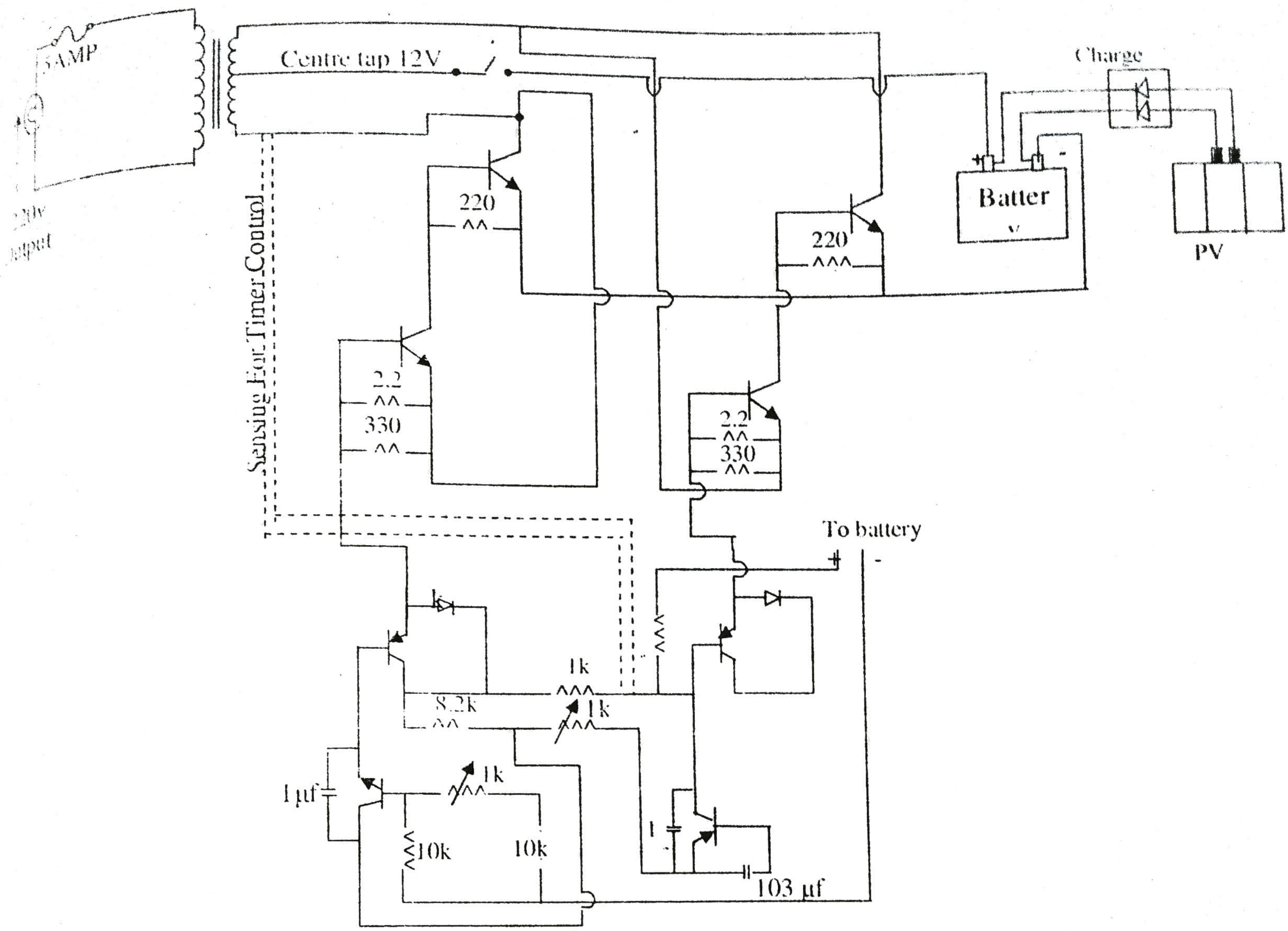

Fig 4 : Complete Inverter Circuit.

Assembling Techniques

The assembling of the solar energy-operated inverter was done by assembling all electronics components first on a breadboard and confirmed their workability before transferring and soldering them on the Vero board.

The photovoltaic modules (PV array) was mounted on a roof of a building at an angle convenient enough so that enough sunlight will strike the array. The charge controller was mounted on plywood at a convenient distance away from the Pv array and connected to the array. The battery was also mounted on plywood separately and placed at a convenient distance from the charge controller and connected to it.

The DC-AC inverter which comprises of the oscillator circuit, inverter switching circuit and the output power transformer was constructed as designed. The oscillator circuit was constructed on a breadboard with the passive components built around it. It was powered by a 12 volts dc tapped from 12 votts dc source (battery) before it was finally transferred onto a Vero board and soldered firmly.

The four power transistors used in the inverter switching circuit was mounted on heat sinks and connected together as

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ISSN 1596 -9770

designed. A 22volts A.C transformer was wound manually with 160 turns in the primary and 1400 turns in the secondary. The transformer was mounted on a plywood and screwed separately. The terminals of the transformer primary were connected to the collector of the switching transistors, with center-tapped terminal connected to the positive terminal of the dc source (battery). The secondary terminals were connected to the socket outlet. The inverter was connected to the Pv array via a 12v, 60Ah battery. The output voltage was then measured. The variable resistor was adjusted until the output voltage was 220v. Various loads were then applied to the output of the inverter.

Results and Discussion

An output voltage of 220 volts (ac) and output current of 2.25 amperes were obtained. But power is given by the product of voltage and current (P = VI). Therefore, an output power of 495watts was obtained. The differences between the expected power and obtained power is due to power loses in conductors.

Conclusion:

The solar energy inverter changes direct current (dc) produced by a solar cell into alternating current (ac) which powers most home appliances. The use of the device will reduce the problem of inadequate power supply in the country and also eliminate noise and environmental pollutions associated with the use of generators which is dangerous to human health.

References

Energy Information Administration (EIA) (2004). Solar Energy-Energy from the Sun. Retrieved May 14, 2004 from World Wide Web: www.eia.doe.gov.

Energy Efficiency and Renewable Energy Clearing house (EREC) (2002). Inverters. Retrieved May 14, 2004 from World Wide Web: ***http:/www. Home power. Com/.***

Federal Republic of Nigeria (2004.Revised) *National Policy on Education*. Lagos: Federal Government] I Printing Press.

Institution of Electrical Engineers (IEE) (1985) *IEE Regulations*. London: Savah Place Publishing Company.

JayCar, E. (2000). Understanding and Using DC-AC Inverters. Retrieved May 12, 2004 from World Wide Web: ***www. Jaycar, Com. Au.***

Ljubisav, S. and George, W.I. (1995). *A power for the world: Solar photovoltaic Revolution*. Canada: Sunology International Inc.

Ndudi, O.C. (2003) *Design and Construction of DC-AC Converter*. Unpublished Masters Thesis of the Department of Vocational Teacher Education, UNN.

Olalekan, A. (1999) Effective Facilities Planning, Management and Maintenance: Tool for Achieving Functional Technology education Curriculum. In G.D. Momoh (Ed), *Issues in Curriculum Development and Innovations for Sustainable Technology education in Nigeria*. Minna: Mega Press.

Okoro, O.M. (1999) *Principles and Methods in Vocational and Technical education*. Nsukka: University Trust Publishers.