Proceedings of the NASEF'06 International Conference, Awka, Nigeria


SOLAR ENERGY SOCIETY OF NIGERIA

# OPTIMIZATION OF A SOLAR MODULE FOR THE GENERATION OF ENHANCED ELECTRICAL POWER

*M.U.Igboekwe and J.N. Agbasonu*
*Department of Physics, Michael Okpara University of Agriculture, Umudike.*
*E-mail: igboekwemu@yahoo.com.*

***Abstract***

*In this paper, a solar module is constructed by connecting a 55-watt solar panel to a charge regulator. From this point a 12-volt battery and a DC load (i.e. a 40- watt electric bulb) are connected .Thereafter a DC to AC converter (inverter) is connected to 12-volt battery from which power can now be tapped for household appliances. It is observed that this panel generates an output voltage of 13.3 volts, and a relative current of 4.1 amps. To maintain this power a good conductor such as a copper wire is used to connect the solar panel and the charge regulator. The length of this wire should not be greater than ten metres. To further enhance this power output it is being suggested that two or more panels of these specifications are connected in series. Alternatively, the cells for this module may be made of doped copper materials rather than silicon chips to give better results.*

***Key words***: *Solar module, inverter, converter, silicon chips, doped copper.*

## Introduction

Solar technology has demonstrated its effectiveness and holds great promise in electrical generation for the world. The process of converting light (photons) to electricity (voltage) is called the photovoltaic (PV) effect. As early as 1839 Antoine Cesar Becquerel exposed a chemical battery to the sun to see it produce voltage (Komp, 1984). The first conversion of sunlight to electricity was one percent efficient and was performed by Smith in 1873.This means that one percent of the incoming was converted into electricity. He further discovered that selenium was sensitive to light.

Charles Frits in the 1880s also used gold coated selenium to make the first solar cells (Headlam, 1995). Again it was only one percent efficient. Nevertheless, Frits considered his cells to be revolutionary and envisioned free solar energy to be a means of decentralization, predicting that solar cells would replace power plants (electric generators) with individually powered residences. Further work brought the cells efficiency up to 15 percent. Solar cells were first used in the rural and isolated city of Georgia as a power source for a telephone relay system, (Douglas, 1995).

Albert Einstein explanation in 1905 of the photoelectric effect, raised people hopes that new solar electricity at higher efficiencies would become feasible. Little progress was made, however, until research into diodes and transistors yielded the knowledge necessary for Bell scientists: Gordon Pearson, Darryl Chapin and Cal Fuller to produce silicon solar cells of four percent efficiency in 1954.

The intensity of the sun determines the amount of power that could be generated in conjunction with the capacity of the solar panel (Onwuka et al, 2002). Modules are compared for performance, including conversion efficiency, power generation and other related characteristics (Murray, 1991; Edelson, 1992; Joel, 1996). As photovoltaic devices and modules have become more complicated so their method of performance evaluation. The more recent evolving thin-film and concentrator technologies have additional complexities and likely yet unknown problems. For instance, because the surface to volume ratios in the thin-film solar cells are extremely high compared with bulk counter parts, materials and environmental interactions are not enhanced, but affect relatively larger portions of the structures. Module design, have recycled some concepts. For instance, silicon module have relatively wide spaces between cells to minimize heating effect, while modules made of thin film have no area wasted between the cells.

This paper is aimed at using the theories of physics to construct a solar module. It is also geared at introducing an enhanced method of electrical power generation whose main objective is the creation of an alternative to the long stressed and over dependent hydro-electric power and fossil fuel as the main source of generating power.

**Theoretical Rudiments and Theory of Components**

On a sunny day when a reasonable amount of sunlight is incident on a solar panel, an appreciable amount of current is generated from the solar panel which is sufficient to run some household appliances.

The basic principles on which this solar module operates are the Einstein photoelectric effect and the electromagnetic principle. When sunlight is incident on the panel the photons are absorbed by these materials. The solar energy knocks electrons hose from their atoms allowing the electrons to flow through the material to produce electricity, which is then distributed to other components. Figure 1 shows the schematic diagram of a solar module whose components are here under explained.

A solar panel is produced with very good semiconductors such as silicon, boron, germanium, arsenic and gallium. Arsenic and gallium are the most suitable semiconductors for effective absorptions of photons for the generation of electricity. Thin film PV panels are manufactured by depositing ultra-thin layers of semiconductor materials on a glass or thin stainless steel substrate in a vacuum chamber. A laser scribing process is used to separate and weld the electrical connections between individual cells in the module. An interface between P and n type silicon is called a P N junction. The fixed charges constitute an electrical barrier, or field which prevents the rest of the holes in the p-side and the electrons in the n-side from mixing (Mc Guraw-Hill 1991, William, 1991; Mohammed, 2004).

A solar regulator, otherwise called, a solar controller, is able to learn the characteristic curve of the accumulator. After the phase of learning, the state of charge (SOC) is displayed with medium accuracy of approximately 10%. This state of charge is the basis of most central and regulating functions. The controller is for use in PV-systems with battery storage in the field of leisure as well as in the living area and in smaller industrial systems. The charge controller surveys the state of charge of the battery controls the charging process as well as the switching on and off of the users. Thus the battery can be used optimally and its service life is prolonged considerably.

The controllers are for used with lead accumulators and liquid electrolyte and can be adapted for use with other electrolytes. Solar regulators are of various types 8A, 10A, 12A, 15A, 20A, and 30A.

Inside a battery, a chemical reaction takes place to maintain the potential difference between the terminals. The chemical reaction overcomes the electrostatic tendency for positive charge to move from the positive to the negative terminal through the battery. As current flows through the battery, the chemical reaction moves positive charges from the negative to the positive terminal. In major constructions, solar batteries are used rather than lead accumulators. In this work, a lead acid accumulator is used.

An inverter is a device that changes a low DC voltage into a stable AC voltage. It is one of the solar energy system main elements as the solar panels generate DC voltage. Inverters differ by the output wave format, output power and installation type. There are two types of output wave formats: modified sine wave (MSW) and pure sine wave (Bullock and Peter, 1981; Chinhiag, 1998)). The MSW inverters are economical and efficient, while the sine wave inverters are usually sophisticated with ligh-end performance and can operate virtually on any type of load. There are basically two types of installation: Standalone inverters and grid connected inverters. Standalone inverters are installed where there is a battery bank .In grid connected inverters; there is no need for batteries.

The sophisticated inverter delivers the power directly from the solar panels into the grid :- Modified sine wave inverters are of various types: PM 150 (150W, 12V) PM 350W, 12V), PM 600 (600W, 12V),PM 1000 (1000W,12V), PM 1500-12 (1500W,12V) , PM 1500-24 (1500W, 24V). Pure sine wave inverters produce a perfect wave from which is similar to normal electricity and are of various types: PM 650 (650W, 12V) PM 1200 (1200W, 12V) PM 1800-12 (1800W, 12V) PM 1800-24 (1800W, 24V), PM 3000-24 ( 3000W, 24V) .

**Construction**

Construction of a Solar Module Cell Module

In this configuration, the cells are electrically connected into series and parallel string to deliver a desired voltages and current. They are encapsulated into a structure of environmental protection. The strength is the elements module configuration. According to Kazmerski, (1997), the materials used for support and encapsulation depend upon the cell type and the application/installation.

When exposed to sunlight of 1AU, a 6-centimeter diameter silicon cell can produce a current of about 0.5 ampere at 0.5 volt. When 10 cells are connected together (module) an average of 7.5 volts is produced. Likewise, if 20cells are connected together an average of 15volts is produced. The most suitable semiconductors used for the manufacturing of solar cells and solar modules are the gallium and arsenic semiconductors. In addition, a module of 90w will deliver a voltage and current of 17.4v and 5.17A respectively.

**Construction of a Solar Panel**

A solar cell shows an open circuit voltage and short circuit current as a function of light intensity from total darkness to full sunlight (100watt/ mÂ²). The short circuit current is directly proportional to light intensity and amounts to 28milliamps /cmÂ² at full sunlight. The open circuit voltage rises sharply under weak light and saturates at about 0.6volt for radiation between 200 and 1000watt/cmÂ². The output voltage can be increased by arranging the cells in series.

The centre n-type and p-type skin in figure 5 forms a junction about 0.0001cm below the surface. Photons of light energy from the sun produce hole electron pairs near the junction. The in â€" built electric field forces the holes to the p-side and the electrons to the n-side. This displacement of free charges results in a voltage difference between the two regions of the crystal, the p-region being plus and the n-region, minus. When a load is connected at the terminals, as electron current flows in the direction shown by the arrow, useful electrical power is available at the load.

k.E (photon) = hf-Ï‰

h is the Planck constant 6.62x10-34 , f is the frequency, Ï‰ is the work function ( which is the minimum energy required to liberate an electron out from the surface.

hf is the input energy of the photon, where Energy of the photon, E= hÏ… = hc/Î» = hf

From the 55w panel we can calculate the relative current using the relative voltage of 13.3v:

Power (w) = EI

DC-AC Converter (solar Inverter)

Fig 6:A single transistor inverter

Figure 6 shows a single transistor inverter. Approximately the same current flows through RL and RE and therefore if RL and RE are equal, the AC output voltages from the collector and from the emitter are equal in magnitude and 180O out of phase. The gain of the circuit is less than unity which is one factor that limits its applicability. A second important factor is that the addition of coupling capacitors and biasing resistors. This is necessary when the circuit is coupled to push pull stage. This causes the phase inversion to be greater than 180O over the frequency range of expected operation.

rms value of waveform ,I r.m.s =1âˆ« 1Ä²dt âˆš T o then I r.m.s = I2dc + âˆšI2 r.m.s(I) + I2 r.m.s. (2) + â€¦ + I2 r.m.s (n)

r.m.s output voltage Vo = 2 + ï¿» To/2 V2 dt Â½ = Vs

Instantaneous output voltage in fourier series Vo = a0 + âˆ' (ancos(nwt) + (bnsin(inwt)) 2 n=1

Vo =â˜' 4Vs sinnwt â€¦1.

N = 1,3,5 nII

The instantaneous load current 10 for a RL load becomes

Io = â˜' 4Vs sin nwt

N = 1,3,5 II â˜š R2 + (nWL)2 â€¦2

Since Vs (t) Is (t) â€" Vo (t) Io (t) (Instantaneous power balance)

Is (t) = 1 â˜š2Vo sin(wt) â˜š 21. sin (wt â€" OI) â€¦3. Vs

Is (t) = Vol Io cos (ti) - Vol Io cos (2 wt - O i) â€¦4 Vs Vs

Ó¨, is the load impedance angle. At the fundamental frequency the output voltage wave forms of ideal inverters should be sinusoidal. However the wave forms of practical inverters contain certain harmonics.

**Assemblage of components**

A solar panel of 55w is connected to some other components by a conductive copper wire of diameter 8mm and length of less than or equal to 10m. Basically the solar panel is connected to the charge controller by the conductive material; the charge regulator is then connected to the DC load (electric lamp, 40w) and a battery of 12v rather than a solar battery. From the battery another connection is made to a solar inverter which converts DC to AC . This inverter is about 220V AC which stabilizes current used for household appliances to prevent them from being burnt by high current. To further enhance this power output it is being suggested that two or more panels of these specifications be connected in series. Alternatively, the cells for this module may be made of doped copper materials rather than silicon chips to give better results.

**Results and Discussion**

This paper is attempt to construct a solar module that produces enhanced electrical power. The construction process consists of the solar panel, DC to AC converter, and a 12V as explained above. Results arising from this construction show that this solar module generates an electrical voltage of 13.3V and a relative current of 4.1amp. Rather than use gallium and arsenic for the production of solar panels copper and aluminum could also be used to increase the efficiency of the panel.

**Conclusion**

In the forgoing we have been able to assemble some solar components that are able to produce enhanced electrical power using a 55W solar panel, a charge controller, a charge regulator and a 12V battery. Results arising from this construction show that this solar module generates an electrical voltage of 13.3V and a relative current of 4.1amp. Rather than use gallium and arsenic for the production of solar panels copper and aluminum could also be used to increase the efficiency of the panel. Furthermore, power gotten from this source is renewable and has no health hazard. It also detachable and has long lifespan. Although this method is currently very expensive there is every hope that it will become cheap in due course. It is therefore being suggested that this method of generating electricity be embraced by our local environments.

## References

Bullock C E. and Peter G. H. (1981) Solar Electricity: Making the sun work for you. Manegen Ltd. London P 530.

Chinhiag H .J (1998); Industrial Electronics, IEEE transactions Volume 45 Toulin city Ltd China pp 99 â€" 107.

Douglas G. C. (1995); Physics: Principles with applications. Prentice Hall Engle wood Cliffs Ltd. New jersey pp 417.

Edelson E. (1992); Solar cell update: Popular science Canada P 95.

Headlam C. (Ed) (1995), Science encyclopedia Volume 8. Kingfisher Ltd. London Pp 629 - 631.

Joel Phipps (1996) Solar Energy: Int solar Energy. Elsevior science Ltd Great Britain PP 207-223.

Kazmerski L. (1997); Photovoltaic: A Review of Cell and Module Technologies. In J. Renewable and Sustainable Energy Review. Elsevior Science Ltd Great Britain pp 71-175.

Komp R. J. (1984) Making and using electricity from the sun. Tab books Ltd London PP 72 88.

Mc Graw-hill (1991) Encyclopedia of Science and Technology MC Graw "Hill book company Volume pp 1043 15.

Muhammed R. H. (2004), Power Electronics: Circuit Device and Applications Prentice Hall of India, India pp217.

Murray Charles J. (1991), Solar Powers Bright Hope: Design News March II London p 30.

Onwuka G. I., Nwabara C. C., Nwokedi P. M., Echendu C. A., Asumugha V. U. and Igboekwe M. U. (2002) Comparative studies of the Efficiency Of Sun Drying, Solar Dryer and Hot Air Oven in the preservation of tomatoes, Okra, pepper and Onion. Nigerian Food Journal. Pp 10 - 14 Volume 20.

William F. L. (1991), An Introduction to Modern Electronics John Wiley and Sons Inc New York pp 21-22.