OPTIMAL OPERATION OF SOLAR PANELS FOR SUSTAINABLE DEVELOPMENT IN NIGERIA.

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ABSTRACT

The maximum power points of a 100watts, 17.5 volts, MBF:100 type solar panel mounted in Ambrose Alli University, Ekpoma, Nigeria for different hours of the day, under various resistive load conditions had been presented. The photovoltaic module exhibits a non-linear irradiance dependent voltage – current characteristics and the maximum power point varies with solar insolation. The maximum power point of 49.53watts occurs at 1.00pm when the sun is overhead. The result shows that the power generated varies with time and cloud transient. Significant power is available for certain time of the day under different load conditions, hence a maximum power point tracker can be used to track this points to dynamically adjust the load so that maximum power is always transferred regardless of the variation in solar irradiance.

Key words: (Solar panel, Maximum Power point, Loads, Power Transfer, Time)

INTRODUCTION

Sustainable energy resources for rapid socio-economic, technological and industrial development had remained one of the desirable objectives of world leaders. The world's energy crisis resulting from the shortage of hydrocarbon due to the prolong decade of crisis in the Gulf region, the endemic hostility in the Niger Delta region of Nigeria cum the environmental unfriendliness associated with hydrocarbon based energy resources necessitated the quest for alternative energy source that are cheaper, renewable, sustainable and can be the catalyst that would drive and sustain the worlds civilization for ever. Solar energy is one of the most promising renewable energy, which provides obvious environmental advantages in comparison to conventional energy sources, thus contributing to the sustainable development of human activities [1]. The quality of solar energy receives at any given point on the surface of the earth depends on its geographical location, time of the day, time of the year and local weather condition. Solar cells convert the suns energy directly to electricity. These cells are arranged in series and parallel combination to form solar panel (photovoltaic array) to obtain the desired output, voltage and current.

Much of the world energy can be supplied by solar power. Besides its availability, it also has many useful characteristics such as collection and power storage, absorption and transmission, which make it one of the most sustainable forms of energy. Power generated by solar panel depends on factors such as geographical location of the site, time of the year, time of the day and local weather conditions. The availability of sunshine throughout the year favoured solar power generation in Nigeria [2].

The terminal voltage and power generated by a solar panel is time dependent [3].

Most industries are focused on the most cost efficient technologies in terms of cost per generated power. The challenges of increasing the photovoltaic efficiency is thus of great interest, both from the academic and economic point of view [4]. The efficiency should be measured under real conditions and the basic parameters that need to be evaluated are the short circuit current and the open circuit voltage. Solar panels operate over a wide range of voltage and current. By increasing the resistive load on an irradiated panel continuously from zero (short circuit) to a very high value (open circuit), the maximum power point for the solar panel can be determined.

At the maximum power point, the product of the voltage and current are maximized' at this point the panel can deliver maximum electrical power to the load at that level of irradiation [5].

In this work the maximum power point of a 100Watts, 12volts solar panel in Nigeria is determined. This was achieved by evaluating the short circuit current and open circuit voltage for various resistive loads for different time of the day. The findings will be imperative to power systems operators and individuals having stand alone solar power system to dynamically adjust the load so that maximum power is always transferred regardless of the variation in lighting.

SOLAR ENERGY EQUATION [6]

The total amount of solar irradiance is

$$R_{gen} = R_{dir} + R_{sca} = R_{hor}Y_{gp} + R_{sca} \quad (1)$$

R_{gen}: Total amount of irradiation on solar panels

R_{dir}: Direct irradiance on solar panel

R_{sca}: Scattered irradiance on horizontal solar panel

R_{hor}: Direct irradiance for horizontal solar panel

Y_{gp}: Geometric parameter of solar panel

The probability density function of solar irradiance can be expressed as

$$F(R) = \frac{1}{B(\alpha,\beta)}\left[\frac{(R-R_{\min})^{\alpha-1}(R_{\max}-R)\beta-1}{(R\max-R\min)^{\alpha+\beta-1}}\right] \quad (2)$$

$$= \frac{r(\alpha+\beta)}{r(\alpha)r(\beta)}\left[\frac{R}{R_{\max}}\right]^{\alpha-1}\left[1-\frac{R}{R_{\max}}\right]^{\alpha-1}$$

Where alpha and beta are parameters related to irradiance characteristic, R_{max} and R are maximum and total amount of irradiance on the solar panels.

By using generation distribution function the possible power generation from solar panel [8] can also be determined by

$$F(P)\frac{r(\alpha+\beta)}{r(\alpha)r(\beta)}\left[\frac{R}{R_{\max}}\right]^{\alpha-1}\left[1-\frac{R}{R}\right] \quad (3)$$

The Energy Conversion efficiency of a solar cell under standard test condition (STC) [7] is

$$\eta = \frac{P_m}{EXA_C} \quad (4)$$

The average daily solar irradiance is at its peak between 12 noon and 1.00pm when the sun is overhead. Solar irradiance, (R) on the panel with efficiency η, temperature factor K and area A and then the output generation will be

$$P = AR\eta K_T \quad (5)$$

MATERIALS AND METHODS

MATERIALS

The materials used in these experiments includes

100Watts, 12Volts, MBF: 100 Type, solar panel, 4mm copper conductor, Digital Voltmeter (DT9205A), Digital Ammeter (DT9205A), Variable resistive Loads and Crocodile Clips.

EXPERIMENTAL PROCEDURES

Two copper conductors of diameter 4.00mm and 20m in length were connected to the terminals of the solar panel mounted on the rooftop of electrical engineering workshop 15m high for direct exposure to sunlight. The other ends of the copper conductors are connected to a variable resistive load of 1- 360Ω in series with digital Ammeter to measure the current flowing through the load, while the digital voltmeter was connected across terminals of the solar panel to determine the voltage. The terminals of the solar panel were short-circuited, the short circuit current and the corresponding voltage were measured, and the product of the voltage and current were computed and recorded. The experiment was repeated for different resistive loads for different periods of the day. These periods were 6.00am in the morning to 6.00pm in the evening (local time) on Saturday 13th March 2010. From the data obtained the power curve for different periods were plotted.

RESULTS AND DISCUSSION

The solar panel operates over a wide range of voltages and currents. Increasing the resistive loads continuously from zero (short circuit) to a very high value (open circuit), on the irradiated panel, the point that maximizes the product of the voltage and current (maximum power point) were determined. At this point the panel delivers maximum electrical power at that level of irradiation. Fig, 1, shows the variation of the generated power with the resistive loads for different periods of the day. The maximum power points for 11.00am (morning), 1.00pm (afternoon) and 6.00pm (evening) , were 35.9, 49.5 and 2.09watts respectively. Beyond 6.00pm the power generated diminishes due to the setting sun. The generated voltages begin to rise again gradually during sunrise at the early hours of the day. This proves further, that the rotation of the earth around the sun places a significant role in photovoltaic power generation.

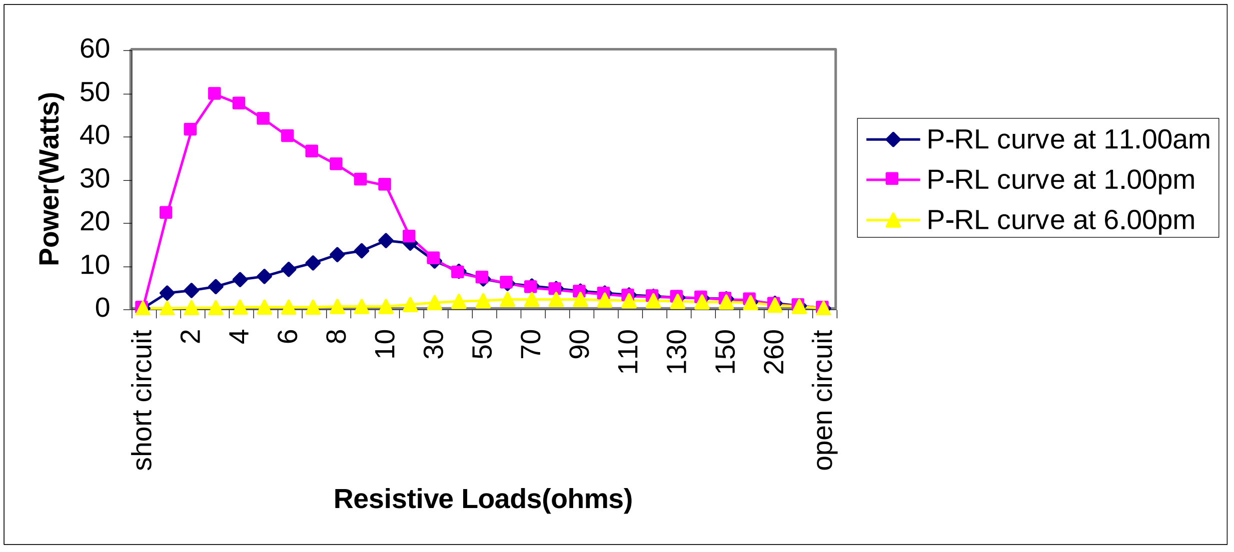
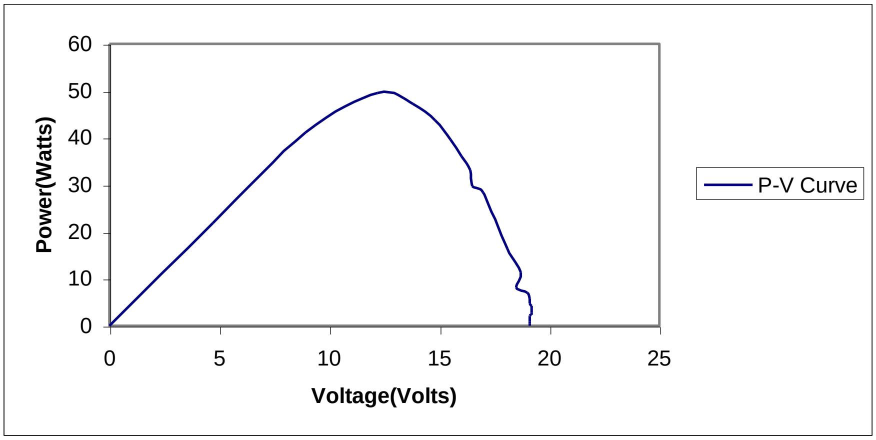


Fig. 1. Power – Resistive Load Curves for different Time of the day

Fig.2 shows the power – voltage characteristics at 1.00pm, the maximum power of 49.53watts can be transferred to a load of 3ohms at rated voltage of 12volts



Fig, 2. P-V Characteristics for 1.00pm

The photovoltaic module exhibits a non-linear irradiance dependent voltage – current characteristics as shown in fig.3.

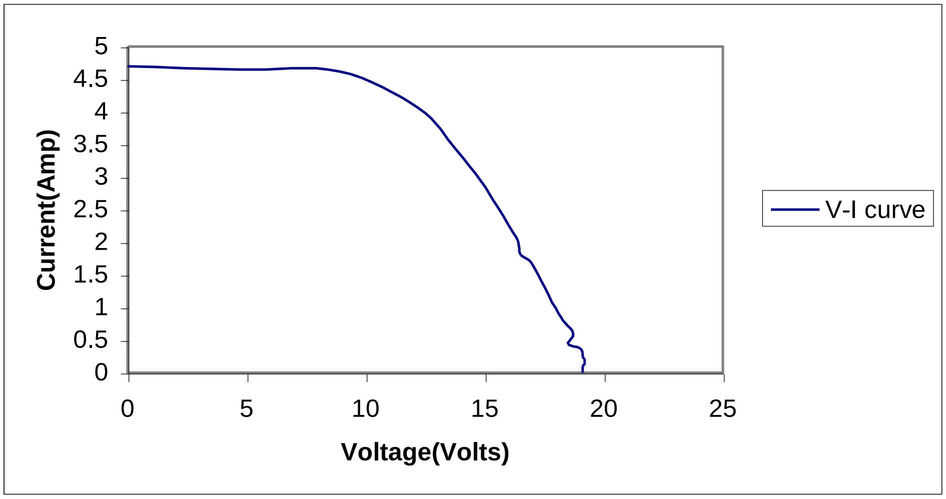


Fig.3. V-I Characteristics of 100W, 12V panel at 1.00pm

The maximum power points between 6am and 6pm is shown in fig.4. The maximum power generated rises gradually due to sunrise, from 0.27watts at 6.00am to 16.11watts at 8.00am. At 9.00pm due to cloud transient, the maximum power drops to 10.3watts. The maximum power point of 49.53watts, occurs at 1.00pm when the sun is over head, beyond 1.00pm the power gradually drop to 2.09watts at 6.00pm.Beyond 6.00pm(sunset) the power generated diminishes to virtual zero, hence storage batteries should be charged with the excess energy generated during the day for night usage.

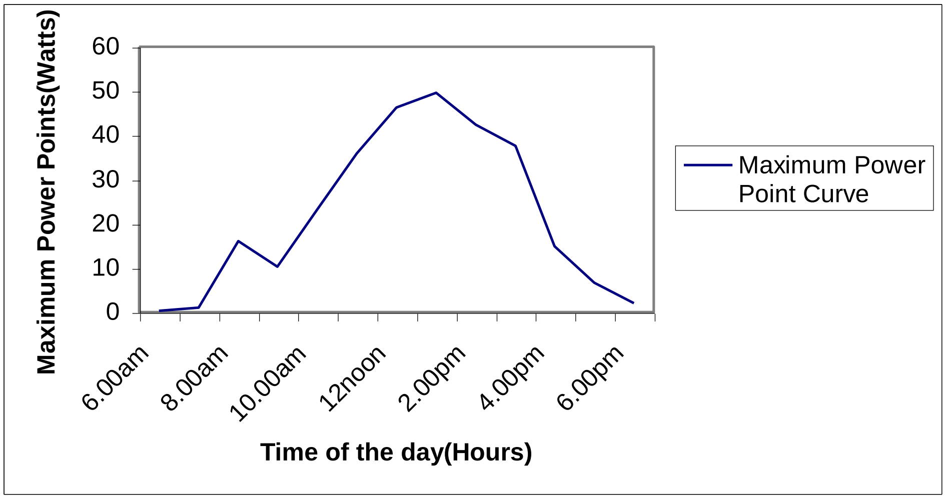


Fig.4. Maximum Power Point – Time characteristics

CONCLUSSION

The maximum power points of a 100watts, 17.5 volts, MBF:100 type solar panel mounted in Ambrose Alli University, Ekpoma, Nigeria for different hours of the day, under various resistive load conditions had been presented. The results shows that significant power is available for certain time of the day under different load conditions, hence a maximum power point tracker can be used to track this points to dynamically adjust the load so that maximum power is always transferred regardless of the variation in solar irradiance.

For the power crises in Nigeria to be solved once and for all, the Government at all levels, corporate bodies, entrepreneurs and individual should invest massively in this environmentally friendly, renewable solar power generation for sustainable socio-economic, technological and industrial development which is pivotal toward jobs creation, poverty eradication and social emancipation of citizenry.

ACKNOLEGDEMENT

We are grateful to the solar energy research group headed by Engr. Evbogbai M.J.E. for the supply of the information and materials for the realization of this work.

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