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Simulation of Effective Power Provision Using Solar Photovoltaic Cells for Essential Load

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ABSTRACT: *This work looked into solar photovoltaic (PV) power designed and construction using Proteus. Algorithm was draw and using MATLAP to simulate the generation of electrical power of 5kW, which was fed into and inverter to generate 6.250VA, 220V, 50Hz for domestic usage. The generation is stable and stabilized, even at cloudy and night weather dip cells and charge controller are used as an alternative to the sun rays for continue electrical power generation. It is best suit for Essential loads powering. This method of electrical power generation will reduce the concentration on most mineral such as the crude oil used in electrical energy generation in the country. The mode of power generation and supply will help in reducing the toxic waste produced from the non-renewable electrical energy generated into the atmosphere. This source of energy will give rise to jobs and technological opportunities.*

KEYWORDS:*Essential load, MATLAB, Photovoltaic,Renewable energy, Simulation*

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I. INTRODUCTION

Electrical energy is becoming one of the fundamental energies that accelerate industrial development and enhance population growth in the world. Methods are being sourced and developed in the generation of electrical energy in Nigeria. Electrical energy is classed into renewable and non-renewable. Non-renewable energy sources are from the fossil fuels – oil, natural gas, and coal etc., while renewable electrical energy sources are from the sun, wind, geothermal, biomass, hydropower and ocean energy etc. Most commonly means of electrical energy generation is from non-renewable methods of electrical energy, whose fuels are scarce and expensive, and the by-products are toxic and pollute the environment. Renewable electrical energy is converted into electrical and heat energy with no cost on fuel and do not pollute our surrounding.

Production of adequate electrical energy to drive modern industrial developments and population growth in Nigeria has been insufficient, inadequate and added to high cost of fuelling and maintenance of non-renewable energy generators. More so, irregular and epileptic national grid power supply system as in domestic power supply in Nigeria has resulted to sourcing other means of electrical power generation. One of the most possible and safest methods is solar photovoltaic (PV) power generation.

II. REVIEW OF LITERATURE

Renewable energy is the energy sources that we can use over and over again [1]-[4]. Renewable energy sources include: solar energy, Wind, geothermal energy, biomass, oceanic and hydropower energies [5]. The disadvantage is that photovoltaic electric power generation is intermittent, depending upon weather conditions and at sun set, but DC/DC booster, deep cells batteries and charge controller are incorporated into the output of the solar PV electric power generator to regulate and stabilize electrical power output from the system. One unique advantage of the Solar PV supply is that, at the point of transmission, the system has the ability to store part of the power generated into the Deep Cells, while transmitting to the Load. Thus, the maximum power point tracker (MPPT) makes the PV system provides maximum power at any instance of irradiance. The energy storing ability necessitates the stability and reliability of the power from PV system, to both loads and utility grid, and hence improve both steady and dynamic behaviour of the whole generation [6]-[7], anti- islanding on the National grid gives reason of not connecting Solar PV to the grid [8]-[10].

III. MATERIALS AND METHODS

The materials and method adopted for the research includes design parameters of solar PV power system, use of flowchart, algorithm and simulation carried out in MATLAB using Proteus software.

3.1 Project Component

- 12V DC, 340W solar panels
- 12V DC, 450mm/1500N actuators
- Sun ray tracker system
- 200AH Deep cycle cell
- 80A charge controller
- Smart distribution Board
- 5kW/12VDC/220VAC,single phase inverter

3.2 Design Parameters

Photovoltaic generator (PVG) system generates 5kW/12V DC
To achieve 5kW from 340W solar panel at 12VDC, number of solar panel needed;

$$\frac{\text{Expectedpower}}{\text{powerfromeachpanel}} = \frac{5\text{kW}}{340\text{W}} = \frac{5000\text{W}}{340\text{W}}$$

$= 14.71 \approx 15$ panels(Shown Fig. 1)

The panels consisting of three units of five set of panels and were connected in parallel to obtain 5kW, 12V DC. The total parallel voltage in the circuit is expressed as:

$$(V_T) = V_1 = V_2 = V_3 = \cdots V_{15} = 12V \quad (1)$$

Total series current output in circuit is expressed as:

$$(I_T) = I_1 + I_2 = I_3 + \cdots I_{15} \quad (2)$$

$$\text{If}(I_1) = \frac{340\,\text{W}}{12\,\text{Vdc}} = 28.3\text{A}, \quad (3)$$

$$I_2 = \frac{340\,\text{W}}{12\,\text{Vdc}} = 28.3\text{A}, \quad (4)$$

$$I_n = \cdots = \frac{340\,\text{W}}{12\,\text{Vdc}} = 28.3\text{A} \quad (5)$$

Then, total current output is:

$$(I_T) = I_1 + I_2 + I_3 + \cdots I_{15} = 424.5\text{A}$$

Total Power output from Solar Photovoltaic Generator (PVG) is:

$$(P_T) = V_T x I_T = 12\text{V}x\,424.5\text{A} = 5094 \approx 5\text{kW}$$

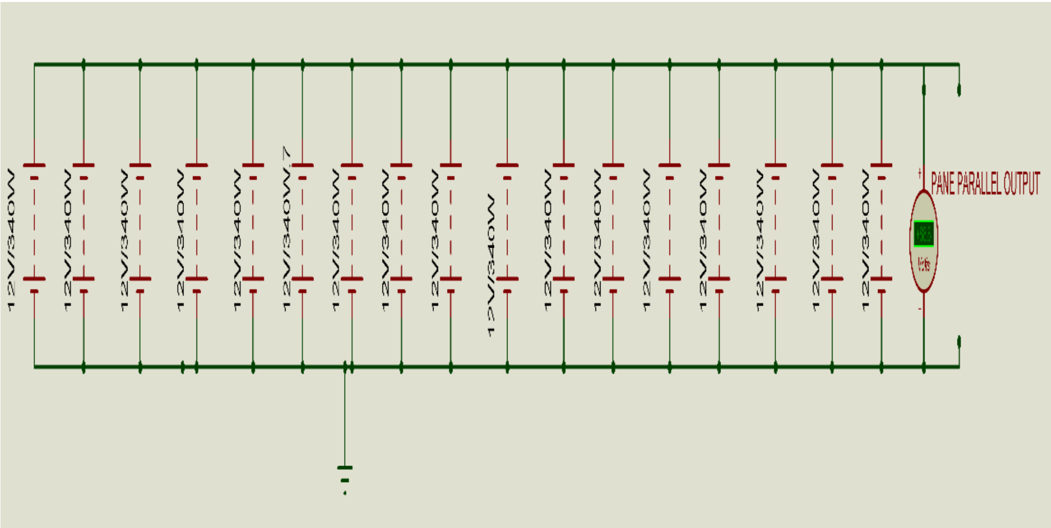

Fig. 1: Solar Panels Connected in Parallel

3.3 Sun Tracker, Maximum Power Point Tracker (MPPT) Actuator

Actuator parameter used: 12VDC, 450mm and 1500N. Approximate mass of each solar panel is 21Kg
:. Weight of each solar panel

$$= 21\text{Kgx } 9.8\frac{\text{m}}{\text{s}^2} = 206\text{N}$$

For a set of 5 panels will require

$$= 206\text{Nx5} = 1030\text{N}$$

Therefore, total number of 3 actuator units will be required with approximately force:$1030\text{N} \pm 470\text{N}$. Fig. 2 shows maximum power point tracking (MPPT) circuit, which was constructed and simulated with Proteus software. The construction usesATMEGA 328 ARDUINO microchip and other electronic components. MPPT has two light dependent resistors (LDRs), i.e. LDR1 and LDR2. These were placed on the solar panels used to monitors the radiations from the sun ray, rising from the west and setting to the east. The differential intensity of the rays from the resistors (LDRs) are sent into ATMEGA 328 ARDUINO microchip used to drive the actuator carrying the solar panels, swinging between the west and the east directions, within approximate maximum period of eight hours of sun light rising and setting for each day. Resistors R1 and R2 of 10kΩ each, connected to the LDRs are coupling resistors between the microchip and the chases. Transistors Q1 and Q2 (BC547) with biasing and coupling resistors R3 and R4 of 10kΩ acts as switches, amplifies the current to the relays RL1and RL2[8]. The relays of 12Vdc and 240Ω are switched on and off from the microchip, resulting in positioning the solar panels at a point of maximum power point from solar radiation. The relays are connected with diodes (1N4007) that makes the relays function in one direction only.

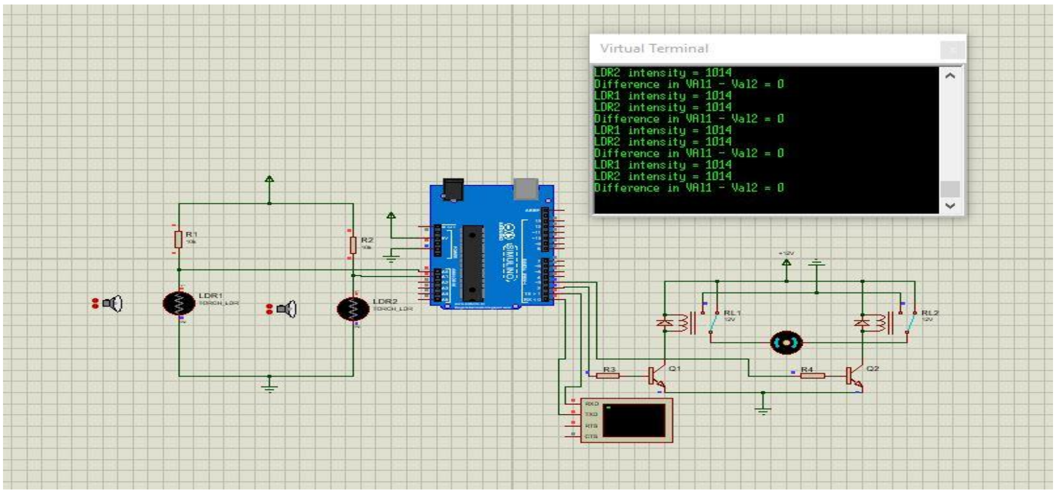

Fig. 2: Maximum Solar Ray Tracking Circuit

3.4 DC-DC Booster

DC-DC booster circuit as shown in Fig. 3, used to stabilize the output power from the solar panels was constructed and simulated using Proteus software [11]-[12]. The circuit consists of LM1578, a switching regulator which sets up DC-to-DC 12V conversion as a buck, or boosts the PV power from the panels. The LM1578 features a unique comparator input stage which not only has separate pins for both the inverting and non-inverting inputs, but also provides an internal 1.0V reference to each input, thereby simplifying circuit design and printed circuit board (PCB) layout. The output can switch 750 mA and has output pins for its collector and emitter to promote design flexibility. An external current limit terminal is referenced to the ground or the V_{IN} terminal. In addition, the LM1578A has an on board oscillator, which sets the switching frequency with a single external capacitor to 100 kHz and offer higher maximum ratings for the total supply voltage and output transistor emitter and collector voltages. The inductor L1 and capacitor C2 serves as coupling devices and any ripple filter to the variable resistor (47kΩ) which is fed to power MOSFETs (IRF1010NS). Power MOSFETs utilizes advanced processing techniques to achieve extremely low on-resistance per silicon area.This benefit combined with the fast switching speed and ruggedized device design that power MOSFETs are well known for, provides the designer with an extremely efficient and reliable device used for voltage stability. Power MOSFETs are coupled with 1kΩ resistors to dc output power. The booster circuit could regulate the voltage from 1.2V to 50V.

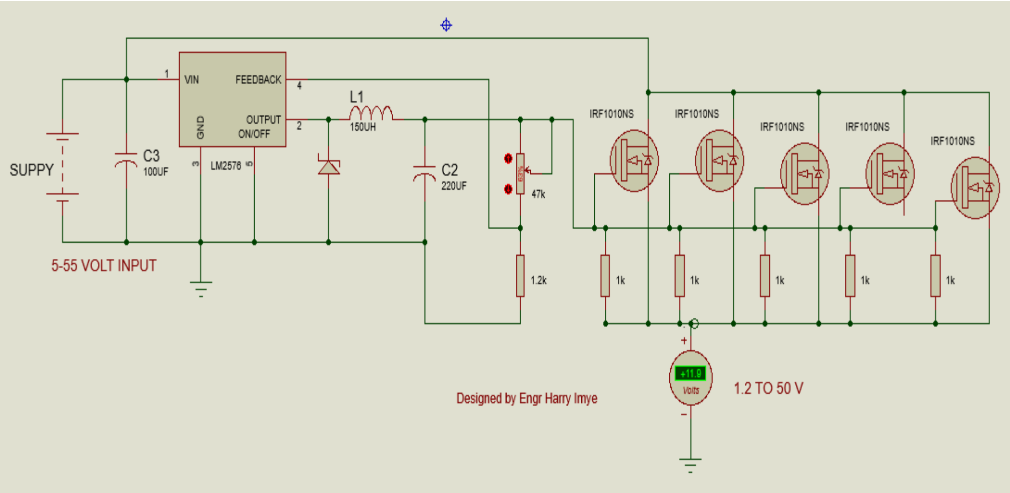

Fig 3: DC-DC Booster Circuit

3.5 Inverter

The algorithm was simulated in MATLAB. Solar PV power (5kW) system, from solar PV arrays, 15 panels in number are connected in parallel at 340W each, are connected to a DC/DC booster to obtain maximum of 5kW at 12V DC[13]-[16]. At this point, the solar PV power of 5,000W sources at 12V with zero phase angle difference [17] was input into the inverter which in turn is converted into alternating power of 6,250VA, 220V and 50Hz into the domestic loads [18].

IV. RESULTS AND DISCUSSION

The results of MATLAB simulation of domestic Solar PV Power supply is presented in Table 1. Fig.4 shows the graphs of DC power of 5kW, voltage of 12VDC and current of 416.67A generated from PV Solar Power Source. Table 2 is illustrated in Fig. 5 showing the inverter alternating output of voltage drop (220VAC), current output of 56.82 A and approximately maximum power of 5kV at 50Hz.

Table 1: Data of PV PowerSource

PV Power Source			
Time in sec.	Power in watts	DC Voltage in volts	Current in amperes
0.36	5000	12	416.6666667
0.24	5000	12	416.6666667
0.12	5000	12	416.6666667
0.08	5000	12	416.6666667
0.06	5000	12	416.6666667
0.048	5000	12	416.6666667
0.04	5000	12	416.6666667
0.034285714	5000	12	416.6666667
0.03	5000	12	416.6666667
0.026666667	5000	12	416.6666667
0.024	5000	12	416.6666667
0.021818182	5000	12	416.6666667
0.02	5000	12	416.6666667

Table 2: Output Data from the Inverter to Essential Load only

Power Essential Loads Only			
Angle in Degrees	Voltage in volts	Power in VA	Current in amperes
0	0	0	0
30	110	3125	56.81818182
60	190.52	5412.5	32.80495486
90	220	6250	28.40909091
120	190.52	5412.5	32.80495486
150	110	3125	56.81818182
180	0	0	0
210	-110	-3125	-56.81818182
240	-190.52	-5412.5	-32.80495486
270	-220	-6250	-28.40909091
300	-190.52	-5412.5	-32.80495486
330	-110	-3125	-56.81818182
360	0	0	0

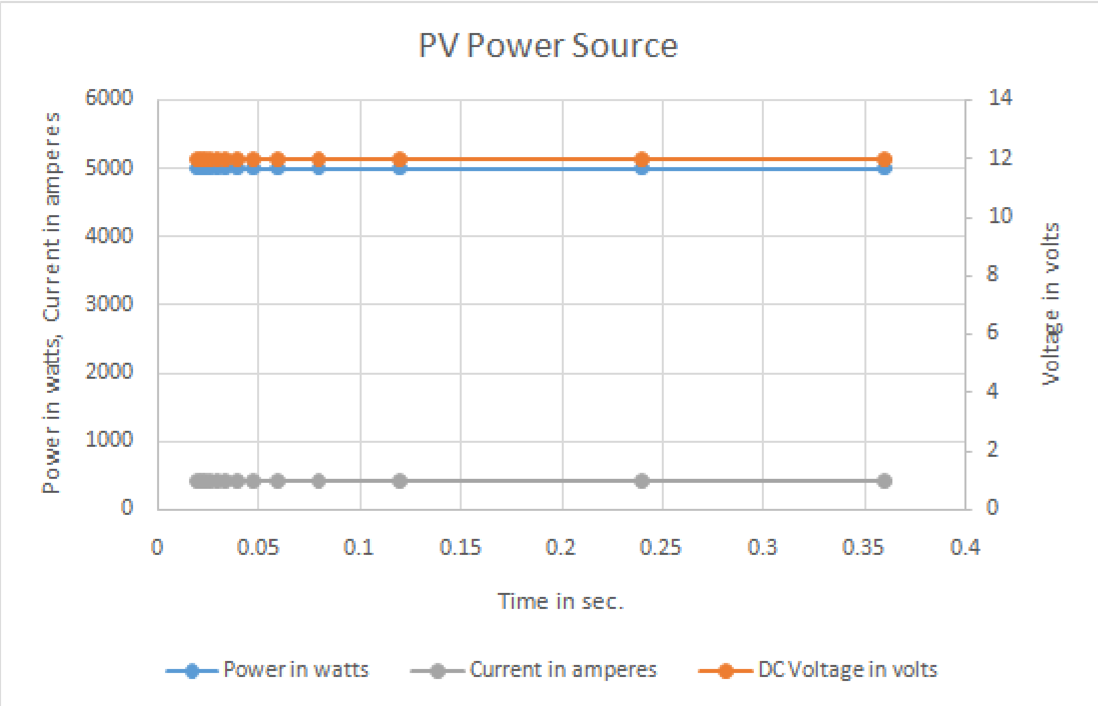

Fig. 4. Electric Power of 5kW/12V Generated from Solar PV Panels

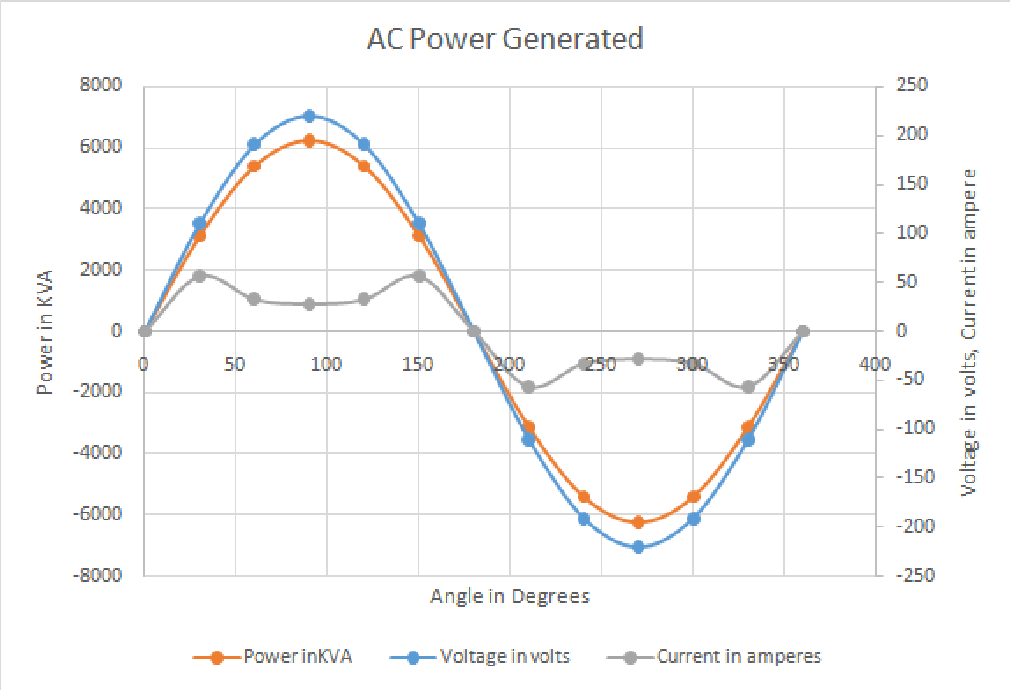

Fig. 5. Electric Power Voltage and Current of from Inverter

V. CONCLUSION AND RECOMMENDATIONS

The work looked at empirical, construction and theoretical method of PV solar power system generation. Preliminary calculations and construction of PV solar system were carried out and tested, with which 15 PV solar panels at 340W at 12VDC each, were connected in parallel, calculated and tested to produce 5000W at 12VDC. Maximum solar ray tracking circuits were constructed usingArduino UNO (ATMEGA 328) ARDUINO microchips and on Proteus software. The tracker tracks solar ray for approximately maximum solar day of 8 hours per day. At cloudy weather DC/DC booster and charge controller boost the solar PV output to 12V and switch to deep cells when the sun sets. MATLAB was used to simulate the solar PV output into the inverter as shown from Fig. 5.

- Nigeria is positioned within the equatorial area of the sphere where solar rays are intense for about 8 hours daily in most months of the year as to exploit the verve from the sun.
- This method of power generation does not create noise pollution in its surrounding and very stable. Absent of toxic waste as compare to Non-renewable method of electrical energy generation
- The toxic waste produced from the non-renewable electrical energy generator into the atmosphere will be reduced when PV solar electrical power generators are used.
- This method of electrical power generation will reduce the concentration on most mineral such as the crude oil dependent in the country.
- The solar rays' as raw material is unlimited and could be converted to produce adequate electrical Power.
- This source of electrical energy generation will give rise to jobs and technological opportunities. In fact individual will be an entrepreneur.
- Since this type electrical energy generation is stable and stabilized, it could use a base power supply during power system interconnection.

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