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Design and Construction of 5KVA Solar Power Inverter System

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ABSTRACTS
This paper presents the design and construction of 5kva solar power inverter system. The solar panelswere installed free from trees/building shade and aligned to receive maximum sun rays at 45^0 North-East. The panels were then connected to the charge controller and the circuit was wired to the battery.It was observed that 7.8 % of the total output power was lost during the testing and measurements which resulted from components used. The output voltage (V_{OUT}) for both expected and achieved values of the solar cell is 100V, the output current (I_{OUTPUT})for the inverter is 10A for expected value and 9.7A for the achieved value. The inverter wasusedextensively with different appliances of diverse power or wattage. However, care was taken not to overloadtheinverterbeyond its maximum power rating of 5kva.Based on testing and measurements during operation, the inverter has relatively small output resistance and low power consumption for its circuitries while delivering optimal output power depending on the wattage of the load.

Keywords: Solar Panel, Battery, Charge Controller and inverter

I. INTRODUCTION

It is a known fact that electric power supply is not reliable in most African countries most especially in Nigeria. There is a significant electrical power supply interruption. Consequently, many electrical instruments develop faults or even stopped working entirely. Therefore crippling many businesses and affecting the economy. Also there is increased occurrence of power supply disturbance, which can be viewed as a form of power pollution. High voltage spikes and momentary voltage drops are therefore common(Tourkhani et al., 2009; Apeh and Olaye, 2015). This power disturbance often affect the performance of sensitive equipment in private and public organization causing loss of data and even damage to equipment. Also, over the years there has been an increase in the earth's population which is directly proportional to the energy used as well (Erol-Kantarci and Mouftah, 2011). With the depleting of fossil fuel reserves, it becomes necessary to identify viable renewable energy resources like solar that can decrease the dependency on fossil fuels as well as reducing the high demands of power supply. Solar energy is the most abundant form of energy available to us. It is approximated that 10000 TW worth of solar energy is incident on earth's surface in a day (Bosshard, 2006).

Previously, Mouftah (2011) worked on construction and implementation of 50 Walt inverter. It was found that, the production of solid state inverters which provides environmentally friendly alternating for un-interruptible power supply for the working of different gadgets and for suitable economy. It was further revealed that, this study is thus anchor on this makeup 50watt inverter. For provision of power using locally sources 25Ah 12colts deep cycle batting. Oscillator determined MOSFETs and a transformer along with other electronic components. In building an inverter for the conversation of direct current (DC) to alternating currents (AC) at a normal frequency of 10HZ, due consideration is given to the switching speed of the oscillator used to make sure that the MOSFETs in their two channels operates in their saturation and cut-off state when

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appropriately driven by oscillator outputs in a way to complement each other.

Also, Apeh and Olaye(2010) worked on design and construction of 100-watt power inverter. It was revealed that, electricity has great control over the most daily activities for instance in domestic and industrial utilization of electric power for operation. The result shown that, electricity can be generated from public support to different ways including the use of water, wind and steam energy to drive the turbine as well as more recently the use of gas generator astral energy and nuclear energy are as well source of electricity.

The use of solar energycan be maximize using a backup device such as inverter. Optimum utilization of solar energy becomes important so as to cut cost in terms of the number of batteries required and to prolong the battery life span in terms of the depth of discharge while in use (Apeh and Olaye, 2015).Inverter is an electrical power converter that changes direct current (DC) to alternating current (AC). It performs the opposite function of a rectifier that converts AC to DC (Messenger and Ventre, 2004).The inverter system has severalstages such as the oscillator, the amplifier, the switching and the transformer stages which work together to achieve the desired AC output. These stages of the inverter systems are so designed to produce output with the desired frequency, phase and voltage which are compatible with that required in household appliances and in industries (Alumona et al., 2016)

II. METHODOLOGY

Components used: Solar panels, charge controller, batteries, and inverter which comprises of transformer, capacitors, relays, resistors, and diodes.

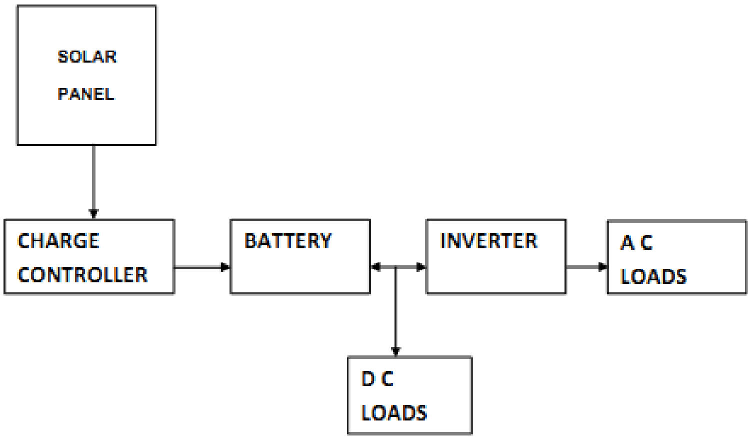

Figure 1: Block diagram of a 5kva solar inverter

Solar Panel

The solar panel is basically a pn junction diode that converts sunlight directly to electricity. The working principle of solar panel is based on the photovoltaic effect. In general, the photovoltaic effect means the generation of a potential difference at the junction of two different materials in response to visible or other radiation. The solar panel works in three steps

i. Photons in sunlight hit the solar panel and are absorbed by semiconducting materials, such as silicon.
ii. Electrons (negatively charged) are knocked loose from their atoms, causing an electric potential difference. Current starts flowing through the material to cancel the potential and this electricity is captured. Due to the special composition of solar cells, the electrons are only allowed to move in a single direction.
iii. An array of solar cells converts solar energy into a usable amount of direct current (DC) electricity.

For this study, Four (4) solar panels of 250 watts each were used to produce 5000W(5kva) of electricity and the energy that was produced was stored in the batteries for use during the cloudy/ rainy weather. The wattage of the Solar Panels was estimated as follows:

5000W/day ÷ 7 sun hours/day = 714.3W
714.3W ÷ 0.8 (system losses) =893W
893/250 = 3.57(approximately 4 Solar panels of 250watts each)

Charge Controller

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The charge controller is an electronic voltage regulator that was used to limit the rate at which electric current was being drawn in or out of the batteries. This charge controller turns off when the battery reaches the maximum charging point and turns on when it goes below certain level. It fully charges the battery without permitting over charge while preventing reverse current flow. Over voltage may reduce the battery performance or lifespan, and may pose a safety risk. This charge controller shows system operation parameters, battery status and protection from over discharge. The charge controller monitors the electricity produced by the solar panel and then regulates the electricity that was used to charge the batteries and prevent them from becoming over charged.

Battery

Without the battery, the system could only power when the sun is shining. The power would interrupt each time the cloud passes, the system would become very frustrating. The solar battery provided constant electricity and the load discharges 80% of its charge. The batteries are the heart of the system and were available in different voltages and various amp-hour ratings depending on the requirement of the system. The battery voltage was kept at above 50% state of charge for maximum battery life. Should the battery is contain wet cells then it would be good to keep the battery's electrolyte level to the indicated level and never let the plates be exposed above the electrolyte. Only distilled water could be used to refill the batteries, over watering dilutes the acid excessively and electrolytes would be expelled when charging.For this study, the required power is 5000W. Therefore, the battery capacity was estimated as follows

$$\text{Battery Capacity (Ah)} = \frac{\text{Total Watt} - \text{hour required } \times \text{Days of autonomy}}{0.85 \times 0.6 \times \text{nominal battery voltage}}$$

$$= \frac{5000 \times 2}{0.85 \times 0.6 \times 24} = 816.9\text{Ah}$$

Inverter

The inverter design starts with fabricating a step-up transformer. A step-up transformer is a type of transformer use for increasing voltage supply to a circuit. The step up transformer consists of two coils called the primary and secondary coils, wounded round a soft iron core that was made of sheets of soft iron (Theraja and Theraja, 2005). The secondary coil of this type of transformer is however greater than the number of turns in the primary coil. The primary winding of this step-up transformer is 24V-DV-24V and the secondary winding is a bifilar winding of 240V. The alternating current which entered into each end of the primary winding induced a alternating current at 50Hz in the secondary winding of the transformer and the alternating current voltage is stepped up by thetransformer causing it to become 240V. The output voltage of the secondary winding is transferred to the socket outlet of the output of the inverter system (Theraja and Theraja, 2005).

Output power of the Transformer:

$$\text{Output power} = V_S I_S \text{Cos}\theta \text{ Watt} \quad (1)$$

Where V_s = Secondary voltage of the transformer, I_s = Secondary current of the transformer and Cosθ = Power factor

$$\text{But } P_s = I_s V_s \quad (2)$$

P_s = 2000VA and V_s = 220V using (2) I_s = 9.1A. Using (1) Cosθ =0.9

From (1) power factor = 1802 watts.

From (2) the output power rating (VA) in terms of the power factor is

$$\text{output power (VA)} = \frac{\text{Output power (Watt)}}{\text{Cos}\theta}$$

$$= 2002\text{VA} = 2.002 \times 10^{-3}\text{MVA}$$

III. RESULTS

The results were obtained using a digital multimeter and the values obtained were compared with the expected values.

Table 1: Measurement and testing of an inverter and solar cell

Measurements	Expected values	Achieved Values
$V_{OUTPUT}$for Solar cell	100V	100V
P_{OUTPUT} for solar Cell	150W	150W
V_{OUTPUT} for inverter	220V	220V
I_{OUTPUT} for inverter	10A	9.7A
P_{OUTPUT} for inverter	5kva	4.83Kva
Frequency	50Hz	50Hz

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Table 2: Measurement of operational time of the inverter with different Load

S/No	Appliance description	Appliances Wattage	Runtime
1	TV Set, DVD Player and home theatre	1360W	15hrs 25 mins
2	Electric Coker	2800W	9hrs 7Mins
3	Electric iron	2200W	10hrs 2Mins
4	5 lighting bulbs (200W each), Standing Fan and Computer system	1750W	13hrs 36mins
4	Washing Machine	900W	20hrs 5mins

IV. DISCUSSION

Table 1 presents the measurement and testing of the inverter and solar cell. TheAC Output voltage from the inverter is 220V with sine wave and the frequency is 50Hz. It was observed that 7.8 % of the total output power was lost during the testing and measurements which resulted from components used. As shown in table 1, the output voltage (V_{OUT}) for both expected and achieved values of the solar cell is 100V, the output current (I_{OUTPUT})for the inverter is 10A for expected value and 9.7A for the achieved value. The inverter wasusedextensively with different appliances of diverse power or wattage as presented in table 2. However, carewas taken not to overloadtheinverterbeyond itsmaximum power rating of 5kva as thiscould lead to the inverterdamage. It was observed that the inverter has relatively small output resistance and low power consumption for its circuitries while delivering optimal output power depending on the power requirements of the load.

V. CONCLUSION

Design and construction of 5kva solar power inverter system was carried out with the solar panels installed free from trees/building shade and aligned to receive maximum sun rays at 45^0 North-East. The panels were then connected to the charging controller and the circuit was wired to the battery.The output current (I_{OUTPUT})for the inverter is 10A for expected value and 9.7A for the achieved value. The inverter wasusedextensively with different appliances of diverse power or wattage.

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