ISSN 2348-1218 (print)
International Journal of Interdisciplinary Research and Innovations ISSN 2348-1226 (online)
Vol. 4, Issue 3, pp: (45-54), Month: July - September 2016, Available at: www.researchpublish.com

Exploiting the Potentials of Photovoltaic Cells in the Extension of Lifetime of a 2.5 kVA Power Inverter for Stable Power Supply in a Developing Nation

Olanrewaju L. Kadir[1], Okechi Onuoha[2], Nnaemeka C. Onuekwusi[3], Nwanyinnaya Nwogu[4], Uzoigwe U. Victor[5], Albert C. Agulanna[6]

[1,2,4,5,6]Projects Development Institute (PRODA), Nigeria
[3]Federal University of Technology, Owerri (FUTO), Nigeria

Abstract: **The perennial yearn of developing countries for stable electricity supply and individual efforts to overcome this challenge are well noted situations. This study basically presents an alternative power generating system (power inverter with Photovoltaic cells backup) that provides electricity to household appliances during failure from national grid. This continuity of supply is achieved by converting direct current (D.C) from rechargeable batteries to alternating current (A.C) at a given frequency and supplying it to the load unit automatically without any noticeable interruption. The system switches over to the mains supply once the public power is restored and back to the inverter during power outage. For improved efficiency and extended lifetime, the system consists of two complementary charging sources that charge the rechargeable batteries. The two charging sources are solar photovoltaic (PV) cells and a rectifier circuit. Detailed design calculations and considerations are shown in the work. Switches are incorporated in the system to switch the source of charging between the charging sources and to establish connection between the load and either the mains or the batteries. The different tests and analysis performed on the system show that the PV cells provide significant improvement on the battery charge (lifetime) of the inverter unlike when the system's only charging source is from the mains.**

Keywords: **Photovoltaic backup, complementary output, inversion, low battery trip, peak inverse voltage.**

I. INTRODUTION

Electrical energy plays an important role in the socio-economic and technological development of any country. While developed countries enjoy stable electricity supply, developing countries are still faced with the challenge of epileptic power supply. To overcome this situation, electricity consumers in developing countries seek alternatives mostly individually. As alternative power supply technologies, the inverters are speedily gaining popularity and gradually replacing the generators because of their low cost of operation, maintenance and environmental friendliness. Power inverter is an electronic system or circuit that converts direct current (DC) stored in a battery to alternating current (AC). It is used to supply continuous power to the load connected to its output. The inverter derives its power from energy stored in batteries and perhaps has its greatest setback emanating from its dependence on the epileptic power supply from national grid to charge its battery. The experience is that most times the inverters may not be readily available as a result of limited lifetime determined by the battery charge. Although the lifetime of inverters is a function of other factors like the reliability characteristics of the inverter, inverter configuration and repair time [1], however in this paper the lifetime is assumed to be only a function of battery charge.

This paper is a development of our earlier work in [8] and is necessitated by our realization of the need for a reliable, effective and better system that will supply electric power continuously to domestic house during power failure from the national electric supply. In [8], the design of a low cost 2.5KVA inverter was undertaken. However, the realization of its short lifetime as a result of low battery charge occasioned by the epileptic power supply from the national grid propelled the need for a backup charging source explored in this paper. Research efforts have shown that electric power generated from photovoltaic cells (Solar panels) can be used as a ready charging source for inverters [2 - 5]. Electricity generated from sunlight is called solar electricity and the process of converting solar light into electricity is known as the photovoltaic process. Energy produced by photovoltaic process can solve the power crisis experienced by developing nations [6]. A photovoltaic or solar module consists of several interconnected solar cells that are embedded between two glass or plastic plates and are therefore protected from the effects of the weather. As a rule, the modules are installed in a frame on a rooftop or a support mount [7]. The design of a 2.5KVA inverter with PV cells as backup for the charging of the inverter batteries is explored in this paper. The paper comprises of five sections. Section one is the introduction while section two presents a brief survey of previous works on the theme of the paper. The design methodology in section three presents the block diagram, circuit calculation and functions of each block. Testing and performance evaluation of the system are presented in section four while section five concludes the paper as well as makes recommendations for further works.

II. PREVIOUS RELATED WORKS

The use of photovoltaic cells (Solar panels) as a ready charging source for inverters has been explored in a plethora of literatures. A market impact assessment of PV inverter systems in the United States of America and by extension the globe was carried out in [7]. Results from this study show that the PV inverter market is booming with significant growth in the residential sector. Research efforts in [9] present the designing of a low powered (25 - 30 watts), portable and cost effective solar micro -inverter wherein the single solar panel is able to run the AC loads along with DC loads. The system consists of a solar panel, DC - DC push -pull converter, DC - AC inverter, LC filter and the test loads. A closed loop analysis was performed on the system and the simulation results obtained show a good agreement with the theoretical analysis presented in the paper. The steady state error was reduced by using PI controller. In a related work in [10], a photovoltaic (PV) based 500W solar inverter system is developed which consists of PV Array, battery bank andsolar inverter cum charge controller. The system works on both solar and AC mains power depending on the energy requirement. The PV based inverter system was designed, analyzed, developed and simulated. The system was tested on resistive and inductive loads. Voltage/current waveform analysis and power quality analysis were carried out using power quality analyzer as well as load sharing between the two schemes of PV array and battery and then battery and mains supply.

The 2.5KVA power inverter discussed in this paper extends the lifetime of the inverter by the incorporation of PV cells which serves as a backup to the mains supply to ensure steady charge in the inverter battery.The batteries will be charged by two complementary sources, a rectifier circuit and solar energy. The rectifier circuit consists of a transformer, a bridge rectifier, a filter and a voltage regulator. The solar energy is obtained from solar (photo-voltaic) cells. An automatic change over system will shift the charging source from national grid in case of the national power supply failure to the solar source. Priority is however set that if there is power supply from national grid the charging source will be from it.

III. DESIGN METHODOLOGY

The system block diagram is shown in Figure 3.1. It illustrates the solar panels and their connection to the inverter system. Descriptions of the constituent units of the entire system as well as some analysis leading to the system realization are presented. The circuit diagram of the system is shown in Figure 3.2.

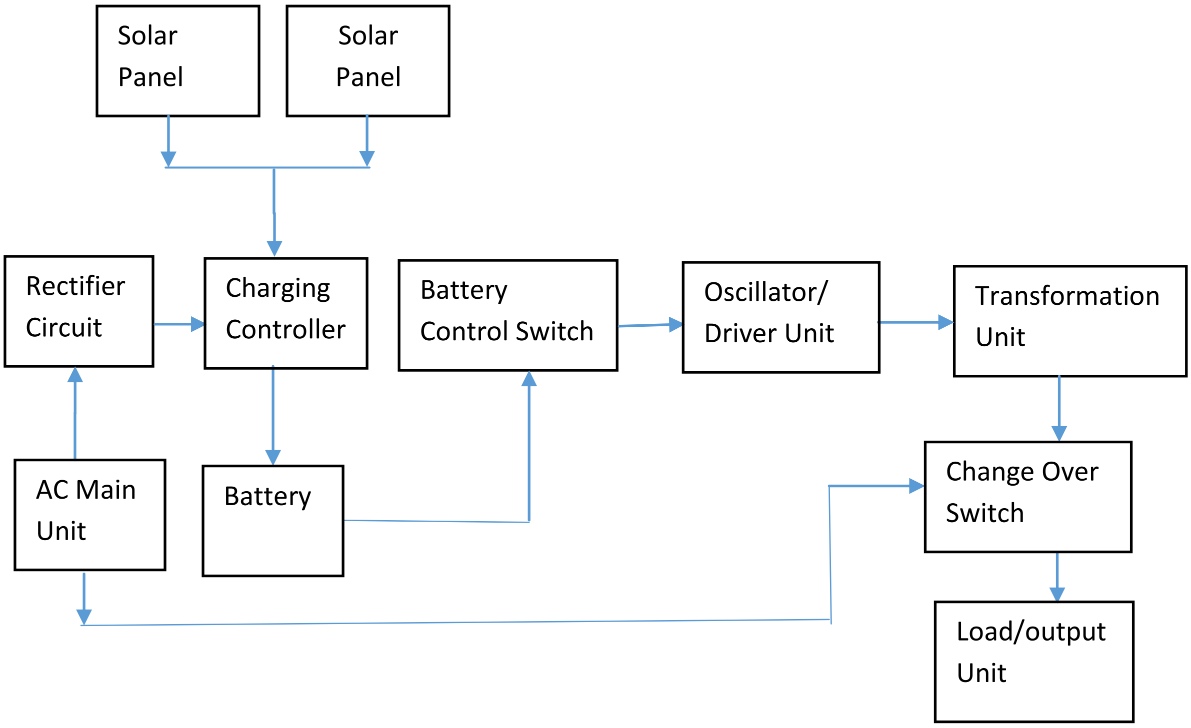

Fig. 3.1: Block Diagram of PV Power Inverter

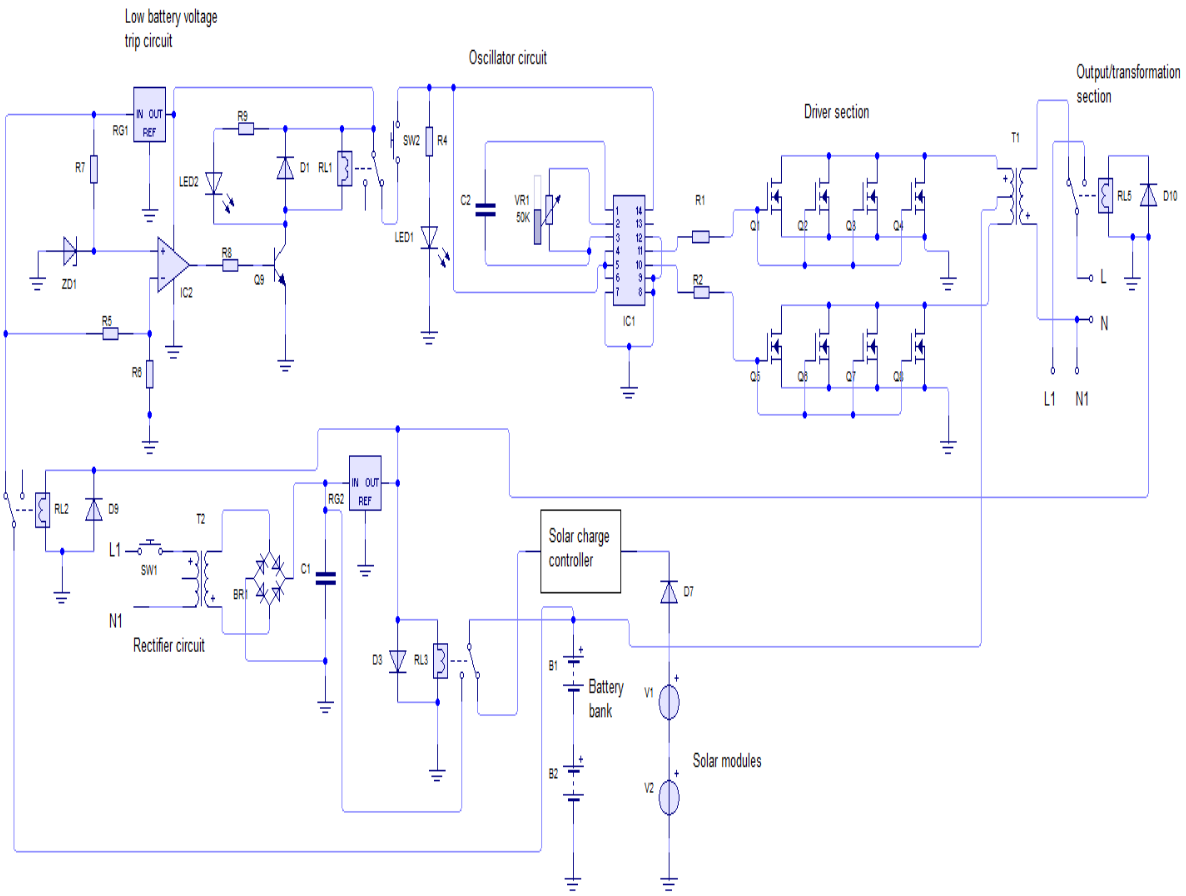

Fig. 3.2: Circuit Diagram of PV Power Inverter

3.1Output Unit/ Load Unit

After the conversion of dc to ac by the inverter, the ac voltage produced is connected to a socket outlet. All the loads (electrical appliances) are connected to the inverter through the socket. A voltmeter may be included in the output to measure the output voltage.

3.2 Change-over unit

This unit is use to change the supply from either the battery or the mains supply. A relay switch is incorporated at the output to perform this function.

3.3 Transformation/Load Unit

A transformer is a static device by means of which electrical power in one circuit can be transformed into another circuit. It can step-up or step-down the voltage in a circuit with a corresponding decrease or increase in current. In its simplest form, it consists of two inductive coils (primary and secondary coils) which are electrically separated but magnetically linked through a path of low reluctance.

In this design a 24/240V step-up transformer (T_1) is used. The transformer has a centre tap which is connected to the positive terminal of the battery.

3.3.1 Determination of the number of turns of coil on each side of T_1 windings

Power rating of T_1 is 2.5kVA (Figure 3.1). The volt per turn is given by

$$E_t = 4.44 f B_{\max} A = \frac{V_p}{N_p} = \frac{V_s}{N_s} \qquad (1)$$

where E_t is volt per turn, f is the frequency in *Hertz*, B_{max}, maximum flux density in *Tesla*, A is the lamination core area in m^2, V_p is the primary side voltage, N_p is the number of turns on the primary side, $V_s$is the secondary side voltage, N_s is the number of turns on the secondary side.

The size of the transformer core must be determined based on the transformer's total power. The area of the core should at least have the value according to the Equation (2). Therefore the area of lamination of transformer T_1 is given as

$$A = \sqrt{power(Watt)}cm^2 \qquad (2)$$

$$A = \sqrt{power(Watt)} \times 10^{-4} m^2 \qquad (3)$$

$$A = \sqrt{IV\cos\theta} \times 10^{-4} m^2 \qquad (4)$$

where *Cosө* is the power factor.

The output power of the inverter is 2500VA. Choosing a power factor of 0.8, then, Area A of lamination was obtained to be $4472 \times 10^{-6} m^2$ and E_t was obtained to be *1.1913volt/turn* using Equations (1) and (4) respectively.

The expected output voltage of T_1 is 240V. Secondary voltage V_s of T_1 is 240V

The number of turns on the secondary winding *(N_s)* is given as

$$N_s = \frac{V_s}{E_t} turns \qquad (5)$$

$$N_s \approx 202 turns$$

Also, the numbers of turns in the primary winding (N_p) is given as

$$N_p = \frac{V_p}{E_t} turns \qquad (6)$$

$$N_p \approx 40 turns$$

3.3.2 Gauge Estimation

Power (VA) is given by IV

Power rating of T_1 is 2500VA. Assuming 90% efficiency, then input rating is

$$P_i = \frac{P_{out}}{eff} \tag{7}$$

where P_i is the input power, P_{out} is the output power and *eff* is the efficiency T_1. The secondary voltage is 240V. The secondary current is

$$I_s = \frac{P_{out}}{V_s} = 10.41 Amperes$$

And the primary current is

$$I_p = \frac{P_i}{V_p} = 57.87 Amperes$$

3.4 Driver Unit

This unit makes use of power MOSFETs. The MOSFETs (IRFP250N) has a maximum current (I_M) and voltage of 30A and 200V respectively. Hence the number of MOSFETs, N_m required is

$$N_m = \frac{I_{p\max}}{I_m} \tag{8}$$

$$N_m \approx 2$$

Hence 2 MOSFETs can safely handle the expected primary current but 4 MOSFETs is recommended for higher reliability.

3.4.1 Signal Generator (Oscillator) Unit

This stage makes use of CD4047 IC for pulse generation of 50Hz. A constant voltage was supplied to the IC from the battery through the voltage regulator IC 7812. It is configured such that pins 4, 5, 6 and 14 were connected to the V_{cc} while pins 7, 8, 9 and 12 were connected to the ground (Figure 3.1). The oscillating frequency (50Hz) was determined by VR_1 and C_2 network. Pin 10 and pin 11 were the output (Q) and complementary output (Q-) respectively. The two outputs separate the signal into two channels. Each channel was connected to the gates of power MOSFETs which was then connected to the ends of primary side of transformer T_1. An electrical signal indicator LED_1 is connected to indicate when the inverter is on. Resistors R_1 and R_2 serve as limiting resistors to limit the current entering the gates of the MOSFETS. The period T of the oscillator was determined using Equations (9) – (11).

$$T = 4.4VR_1C_2(\mathrm{secs}) \tag{9}$$

and

$$T = \frac{1}{f} \tag{10}$$

$$f = \frac{1}{4.4VR_1C_2} \tag{11}$$

Choosing C_2 to be 100*nf (100 nano Farad)*, VR$_1$ was obtained to be 45.45kΩ.

From manufacturer data sheet, when the voltage at pin 14 is 12V, the output voltage and current at pin 10 and pin 11 of IC4047CD are 5.6V and 50mA respectively. The value of resistors R$_1$ and R$_2$ were obtained using Equation (12). V_{out} at pin 10 and pin 11 of IC 4047CD are $5.6V, V_{gs} = 0$ and $I_{max} = 50mA$

$$R_1 = \frac{V_{out} - V_{gs}}{I_{\max}} \tag{12}$$

R_4 was obtained using Equation (13), which is given by

$$R_4 = \frac{V_{cc1} - V_{LED1}}{I_{LED1}} \tag{13}$$

Where V_{cc1} is 12V from RG_1, V_{LED1} is 2V and I_{LED1} is 10mA from manufacturer specification.

3.5 Battery Control Switch Unit

This unit is used to disconnect the battery from the inverting section whenever there is power supply from the national grid. This unit makes use of relay switch.

3.6 Battery Bank

A battery is an electrochemical device that converts electrical energy to chemical energy during charging and chemical energy back to electrical energy during discharging. A battery bank is needed in solar design to store the energy generated by the solar modules and then used when there is no sunlight (at night) or when there is no power supply from the national grid. Deep cycle battery type is recommended in solar design because they are specifically designed for charge and discharge for a longer time. The battery should be large enough to store large amount of energy to operate the household appliances for predicted or expected number of days of no light from the national grid. Two 12V/200Ah deep cycle batteries connected in series will produce an output of 24V when fully charged. The batteries will be charged by two complementary sources which are the rectifier circuit and solar modules. But the priority was that when there is supply from the mains, the source of charge should be from it. Measurements were taken from battery bank to know how it is being charged and discharged.

3.7 Charging Controller

The rate at which electricity is been added or drawn from the battery needed to be controlled. The charging controller is used to protect the battery from over-charging and over-drainage. The charging controller consists of solar charge controller and low battery voltage trip.

3.7.1 Solar Charge Controller

To control the rate at which the solar modules charge the battery, a solar charge controller is required. The solar charge controller used here was bought and incorporated in the design. The characteristics of the solar charger are as shown in Table 3.1.

Table 3.1: Solar Charge Controller

Model	ASC-MPPT-200
Maximum PV array Power	400W
Operating Voltage	30V – 44V @ 24V
Maximum Current	12A
Nominal Voltage	24V

3.7.2 Low Battery Voltage Trip

The inverter obtains its energy from the battery(s). If there is a prolong drainage from the batteries without charging, the life span of the batteries will be affected and therefore require a protection. The low battery voltage trip performs this function by disconnecting the oscillating section from the battery when the voltage across the series connected batteries has reduced to certain level. LM324 comparator (IC_2) and zener diode ZD_1 were used as shown in Figure 3.1. Pin 1 is the output terminal, pin 2 is the non-inverting terminal and pin 3 is the inverting terminal. Pin 2 of the op-amp is set to a constant voltage of +10V by ZD_1. Pin 3 is set at a lower voltage of 9V through potential divider formed by R_5 and R_6. As the batteries are discharging, the voltage at pin 3 will be reducing. When the voltage at pin 3 becomes lower than the voltage at pin 2, it results to a high voltage at pin 1 which will bias the transistor Q_9 through resistor R_8. This triggers the relay connected to it thereby disconnecting the batteries from oscillator. At pin 2, the inverting terminal,

$$V_{R6} = \frac{R_6 \times V_{cc2}}{R_5 + R_6} \tag{14}$$

where V_{cc2} is the battery voltage, V_{R6} is the voltage across the inverting terminal set to 9V by potential divider formed by resistor R_5 and R_6. Choosing R_5 to be 1kΩ, $R_6$was obtained to be 1kΩ from Equation 14

At pin 3 (non-inverting terminal), the zener diode $Z_{D1,}$ is set to a voltage of 10V.

$$V_{cc2} = R_7 I_{Z\,D1} + V_{Z\,D1} \tag{15}$$

where V_{ZD1} is the zener diode voltage, 10V and I_{ZD1} is the zener diode current, 10mA. R_7 was obtained to be 1kΩ from Equation 15.

The transistor C1815 (Q_9) has the following specifications from the data sheet.

$I_{cmax} = 0.5A$, $V_{BEmax} = 5V$, $\beta = 100$

Output voltage of the op-amp = $0.9 \times V_{cc3}$

Where $V_{cc3}$is the voltage regulator output voltage to power the op-amp.

Output at pin 1 = $0.9 \times 12 = 10.8V$

Thus, $V_{BB} = 0.9V_{cc3} \times 10.8$

$$R_8 = \frac{V_{BB} - V_{BE}}{I_B} \tag{16}$$

and

$$I_B = \frac{I_C}{\beta} \tag{17}$$

For LED_2

$$R_9 = \frac{V_{cc1} - V_{LED2}}{I_{LED2}} \tag{18}$$

Where $V_{cc1} = 12V$, $V_{LED2} = 2V$ *and* $I_{LED2} = 10mA$. From equations 23, 24 and 25 R8 and R9 were obtained to be 2kΩ and 1kΩ respectively. Diode D_3 is IN4007. It has a peak voltage of 50V and a maximum current of 7A, it can safely protect the relay from inverse voltage.

3.8 Rectifier Unit

Battery(s) or a battery bank is needed in the design to store the energy from the PV modules or from the supply mains. The power from the supply mains is an AC supply which cannot be used to charge the batteries directly. Therefore a rectifier circuit is needed to change the ac supply to dc supply to charge the batteries. The rectifier consists of a 220/30V transformer (T_2) and the bridge rectifier consisting of four diodes, D_1 – D_4. The diodes convert the ac voltage at the primary side of T_2 to dc voltage at the secondary side. The diodes have a peak inverse voltage of 100V, and a maximum current of 30A which can safely handle T_2. The capacitor C_1 is used to remove the ripples from the rectified voltage. Equations (19) and (20) were used to obtain the value of C_1 (6000µF).

$$I_c = C_1 \frac{dv_c}{dt} \tag{19}$$

$$t = \frac{1}{f} \tag{20}$$

3.9 Solar Panels

There are many sources of renewable energy that are available in the universe. These include Wind, Solar, tides, waves and geothermal heat. These renewable energy can be converted to other forms of energy. Among these numerous sources, solar energy occupies a very important place. The solar energy can replace convectional fuels used in electricity generation.

Solar power system (Solar photovoltaic system) consists of photovoltaic cells (PV cells or modules) which are light sensors that generate electricity when illuminated. The electricity generated can either be stored or used directly. Solar PV system is very reliable source of electricity that can suit many applications including residential buildings. Solar power system is more expensive to install, but it is cheaper than mechanical generator due to low or no maintenance. Solar powered systems have a technical life time of 20 – 30years and they could prove much more reliable than operation on diesel generator system which needs regular maintenance and re-fuelling. In terms of the environmental impact, the alternative source (Solar) produces no noise, CO_2 emission or smell, thereby reducing environmental pollution.

The PVcool-SP95 solar modules were used. Two modules were connected in series to increase the output voltage while the current remains the same. Table 3.2 shows the characteristics of the solar module. The modules were taken outside where they can receive direct energy from the sun and then connected to battery bank.Appropriate measurements were then taken.

Table 3.2: Characteristics solar module.

Module type PVcool-SP95	
Maximum Power, P_{max}	200W
Maximum Power Voltage,V_{mp}	18.7V
Maximum Power Current,I_{mp}	10.8A
Open Circuit Voltage, V_{oc}	22.5V
Short Circuit Current, I_{sc}	11.32A
Length, L	1037mm
Width, W	527mm
Thickness, T	54mm

3.10 Power Consumption Demand for Household

At household level, electricity is used for services such as lightings, heating, cooling cooking and for electronic appliances. Cooking and other power consumption equipment consumed a lot of power and their inclusion in design will increase the power required from the system which will also results in high cost of using the system. Therefore most power consuming equipment are not considered in this design. Table 3.3 depicts typical power consumption of demands of a household.

Table 3.3: Typical Power Consumption Demands for Household

Components	Power Rating (W)	No. Used	Total Power (W)
Lightings	30	8	240
Ceiling fans	80	4	320
Televisions	80	2	160
Home theatres	250	2	500
Decoders	30	2	60
Computers	100	2	200
Refrigerator	500	1	500

IV. PERFORMANCE EVALUATION

To ascertain if the desired objectives were achieved, the power inverter was tested. The system output voltage was measured at no load as shown in Table 4.1.

4.1 Output Voltage at no Load

Table 4.1: Output Voltage at no load

Measurement	**Specified (V)**	**Achieved (V)**	**Correlation (%)**	**Remarks**
Output Voltage (inverter mode)	240	242.5	98.9	Satisfactory
Output Main Supply	220	220	100	Satisfactory

4.2 Charging Tests

Though deep cycle batteries were produced to undergo charging and discharging for long period of time, the batteries should be protected from overcharging to prolong their life span. Overcharging test was carried out to ensure that the batteries were not overcharged by the charging sources. The test results are as shown in the following tables.

Table 4.2: Charging Test

Battery Voltage (V)	**Indicator**	**Remarks**
18	ON	Satisfactory
20	ON	Satisfactory
22	ON	Satisfactory
24	ON	Satisfactory
25	OFF	Satisfactory

4.2.1 Solar Charging Test

The test was carried out to know the effectiveness of solar charging source. This was carried out during the day time. The solar panel was mounted to receive direct energy from the sun. The reading was taken from 8am to 6pm for three days. The result is as shown in Table 4.2.1.

Table 4.2.1: Solar Charging Test

Time of the day	**Charging Current Day 1**	**Charging Current Day 2**	**Charging Current Day 3**	**Mean Value**
8. 00 AM	1.42A	1.44A	1.45A	1.44A
10.00 AM	2.54A	2.59A	2.63A	2.59A
12 NOON	3.53A	3.59A	3.62A	3.58A
2.00 PM	4.31A	4.26A	4.33A	4.29A
4.00 PM	3.88A	3.94A	4.00A	3.94A
6.00 PM	1.84A	1.88A	1.90A	1.88A

It will be observed from Table 4.2.1; the solar charging source was very effective. The charging current from the solar modules depends on the time of the day. The solar charging source thus has the maximum charging current between 12 PM noon and 4.00 PM.

The charging current from supply mains was also measured and it was found to be 6.54A at 220V. Though the charging from the supply mains is more effective than the solar source but the current fluctuates due to fluctuation in the supply voltage from the main supply.

The change-over between the charging sources was also tested. The test was carried out during the day time (2.00PM) when the sun is high and there is availability of supply from main (national) grid. It was observed that the charging source was from the supply mains. When the main supply is switched off the charging source automatically changed to solar source.

4.3 Over-Drain Test

To protect the battery from too much drainage, low battery voltage trip was incorporated in the design. Over-drainage test was carried out to confirm the function of the low battery voltage trip. After the batteries were fully charged, the charging sources were removed and the system was powered ON. The oscillator and the system output voltage were measured at different battery voltage. The results are shown in Table 4.3.

Table 4.3: Over-drain Test

Battery Voltage (V)	Oscillator Voltage (V)	System Output Voltage (V)	Remarks
24	5.6	242.5	Satisfactory
22	5.6	222.4	Satisfactory
20	5.6	203.2	Satisfactory
18	0.9	0	Satisfactory

4.4 Output Power/Load Test

The duration of supply from the power inverter is a function of total load connected to it and the power rating of the battery. The series connected batteries were rated 24V, 200Ampere-hour (24V/200Ah). The power inverter was tested with all the appliances shown in Table 3.3. The duration of supply from the battery was found to be 3hrs, 13 minutes. This implies that the duration of supply from the battery can be improved by connecting more battery to the system.

V. CONCLUSION

The solar modules served as an alternative source of charging to batteries. It was observed that the charging from the sun is more effective between 12 noon and 4.00 PM. The change-over between the charging sources was also effective as the priority was given to the main supply to charge the batteries if the two charging sources are available. The power inverter output was usable for all the connected household appliances. All the tests carried out on the system were satisfactory.

The flexibility and well automated nature of the design eliminates the need of human operator after been set up, thereby facilitating efficient and reliable use of batteries and the inverter. Since the power inverter does not depends only on the supply from the national grid to charge the batteries, the reliability and availability of the system has been improved. However, further research work need to be done on the use of wind as third source of energy. This energy can also be made to charge the batteries to further increase the reliability of the system. Also the capacity of the system can be increased so that more equipment can be powered by the system.

REFERENCES

[1] A. Pregelj, M. Begovic and A. Rohatgi, "Impact of Inverter Configuration on PV System Reliability and Energy Production" 2003.http://www2.ece.gatech.edu/research/UCEP/papers/inv_impact.pdf.

[2] W. Bower, C. Whitaker, W. Erdman, M. Behnke, and M. Fitzgerald,"Performance Test Protocol for Evaluating Inverters Used in Grid-Connected Photovoltaic Systems" p. 20, 2008.http://www.gosolarcalifornia.ca.gov /equipment/documents/2004-11-22_Test_Protocol.pdf.

[3] California Energy Commission and California Public Utilities Commission, "Go Solar California", 2010. http://www.gosolarcalifornia.ca.gov/equipment/inverters.php.

[4] F. Ahammed, D. A. Taufiq, "Applications of Solar PV on Rural Development in Bangladesh", Journal of Rural and Community Development, vol. 3, pp. 93-103, 2008

[5] M. Shiao, "The Global PV Inverter Landscape 2013: Technologies, Markets, and Survivors", GTM Research, 18 April 2013, http://www.greentechmedia.com/research/report/the-global-pvinverter-landscape-2013

[6] N. Chowdhury, S. E. Reza, T. A. Nitol, A. I. Mahbub, "Present Scenario of Renewable Energy in Bangladesh and a Proposed Hybrid System to Minimize Power Crisis in Remote Areas", International Journal of Renewable Energy Research-IJRER, vol. 2, no. 2, pp. 280–288, 2012

[7] Energy Star Market and Industry Scooping Report Solar December, "Solar PV Inverters", 2013.https://www.energystar.gov/sites/default/files/asset/document/Solar_PV_Inverters_Scoping_Report.pdf

[8] O. L. Kadir, O. Onuoah, N. C. Onuekwusi, U. Onochoja, C. N. Udezue, " Development of Cost Effective 2.5kVA Uninterruptible Power Supply", American Journal of Engineering Research,Vol. 5, Issue 2, pp 125 – 135, February, 2016.

[9] A. Menon, R.Madhumitha,"Design andSimulation ofSolar Micro-Inverter withMultiple Loads", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering Vol. 3, Issue 5, May2014.

[10] V. Kulkarni, R. Nehete,"Simulation and Analysis of Photo-Voltaic (PV) based Solar Inverter System", International Journal of Soft Computing and Engineering (IJSCE),Volume-3, Issue-6, January 2014.