International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 6 Issue 4, May-June 2022 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Design and Implementation of a 30KVA Hybrid Inverter (Solar and Utility Supply)

Makinde Kayode & Ibrahim Abubakar

Department of Electrical Engineering, Federal Polytechnic Bida, Niger State, Nigeria

ABSTRACT

The greatest desire of mankind is to have reliable and sustainable electricity. Over the years, conventional, non-renewable energy resources (e.g. coal, oil, fuel wood etc) had been harnessed to generate electricity. However, these resources are depleting with constant usage. This had initiated a switch in attention to renewable energy sources like wind, solar, tidal energy etc. This paper therefore, demonstrates the design and implementation of a 30KVA hybrid inverter using solar panels and utility supply as means of charging so as to generate reliable and sustainable electricity. To achieve this, hybrid inverter with solar charging system that consists of an inverter powered by a 192VDC battery was used. The solar panel converts solar energy to electric energy and charge up the batteries during the day with the help of MPPT charge controller, the charge controller was able to accommodate 200VDC from the solar panel and deliver an output voltage 192DCV while converting the excess voltage to current at 192V/100A to the battery. During the test of the solar panels, the results obtained showed that the solar panels were more than sufficient to charge the 3200AH batteries that were connected in series and parallel arrangement and it provided a 24 hours uninterruptible power supply. With poor weather (low sun intensity) or at night or when there is grid availability, the hybrid inverter self-charge the batteries. The system operate at minimum running cost, pollution free environment, noiseless, reliable and provide the convenient of a twenty-four hour power supply. With this system, energy efficiency was achieved.

KEYWORDS: *Hybrid power supply, Power reliability, Solar Polar, Inverter, MPPT charge Controller*

How to cite this paper: Makinde Kayode | Ibrahim Abubakar "Design and Implementation of a 30KVA Hybrid Inverter (Solar and Utility Supply)" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-6 | Issue-4, June 2022, pp.1772-1777, URL: www.ijtsrd.com/papers/ijtsrd50253.pdf

IJTSRD50253

INTRODUCTION

Power supply from the national grid is inefficient and unreliable, hence the need to provide alternative source of power. Electrical power supply from renewable sources is advantageous as the increasing electrical demand is a scientific contribution to the peak demand on the grid. As individuals and companies generate their power through renewable energy, the stress on the grid is reduced. However, there is an ongoing interest in the possibility of making wider use of renewable energy, particularly in homes, offices and industries, for the purpose of lighting, heating and powering of appliances. In most rural and sub-urban regions in Nigeria, inhabitants do not have access to electricity supply. Where the electrical energy is available, it is not reliable; hence inhabitants resort to other forms of energy such as wood, paraffin, and diesel generators, which pollute the environment and cause harm to man and plants [1]. Two methods of energy generation will be discussed here, the conventional (hydro for instance which falls under utility supply) and the non-conventional (solar energy). Constant supply and availability of electricity is unarguably an important need that must be filled to make day to day living more comfortable and enjoyable. Thus, provision of constant electricity is a goal to which several countries of the world press forward [2]. Using conventional electricity generation techniques, such as burning fossil fuel is no longer solution to this crux. More over burning the fossil fuel will result environmental problems. The emission of carbon dioxide, methane and other greenhouse gasses will result in global warming. He discovered that most of the researchers have focused their concentration on renewable energy and actively looking for cost effective solution of this crux [3].

AIM AND OBJECTIVE

The aim of this work Design and Implementation of a 30KVA Hybrid Inverter using utility supply and solar as means of charging the batteries The following are the objectives of this design;

- To design and implement a solar-hydro hybrid power system
- To use the complete system domestically to provide sustainable electricity irrespective of changes in weather conditions.
- To ensure that the system is available for use throughout the day.

SCOPE OF THE DESIGN

As stated earlier, this work involves the design of a hybrid power system that is made up of utility supply (hydro) and solar power. This implies that the design will initially be divided into two parts; the design and implementation of a functional solar generator to produce DC energy for charging of the battery in the day or when there is outage of utility supply while the second part involves the installation of a delay circuit between the inverter and the utility supply system for the purpose of charging the battery at low weather or at night without damaging the inverter due to surge that is usually experienced by utility companies of Nigeria. A charge controller is also included in the hybrid systems. This circuit receives direct current (DC) outputs of solar and outputs a DC voltage that is just suitable to charge the battery and this controller is also controls the charging process of the battery by supplying just the right amount of voltage needed to prevent over-charging. Furthermore, an inverter is also included in the system; it converts the DC voltage of the battery to alternating current (AC). Thus, AC loads e.g. LED bulbs, air-conditioner, ceiling fans or pumping machine can be powered through the output of the inverter. Some researchers carried out a comprehensive review of life cycle assessment (LCA) and life cycle cost (LCC) implication on residential buildings. It critically illustrates the existing LCA and LCC studies on residential house designs to determine the causes for the widely varying results of numerous previous studies. It is a review paper, nothing was implemented. All works reviewed were bridged and implemented [4]. Similarly another research was done on a designed of small scale off-grid solar energy plant. It was used for battery storage plant in an isolated hut house on an island located 25 km away from the city. This was done in order to identify the power demands of the location and select the most appropriate hardware such as solar panels, batteries, charge controller, inverter and size of cable needed for an installation. However, the designer did not make provision for service box (disconnect switches) between panels and charge controller and AC output, in case a part needed to be isolated for repairs. In the design and implementation provision was not only made for service box, rather service box and combiner box was incorporated [5]. And another author worked on design of a 3kva hybrid power supply system. The design was made for 18-unit computer laboratory to carry out experiment. The designer used a 560W-24V solar panel and a PWM charge controller for the hybrid system. This configuration is not a match to the load in question and it cannot charge the batteries sufficiently in a day. Similarly the type of controller used cannot convert excess voltage to current. All of these were taken care of in the new design [6].

METHODOLOGY

DESIGN AND IMPLEMENTATION

Methodology

The solar system can be designed for hybrid system in which the load is supplied by the solar PV system which is intermittent in rainy seasons. So other way is the independent system (utility grid) in which load can be supplied from both solar system and also from other alternative supplies which increases the reliability of supply also reduces the losses that incurred due to stand alone system. This aspect presents the techniques used in this design. It describes the procedures for carrying out the work. The step by step approach ranging from survey down to testing and implementation of the complete it also covers the major components that are used in the circuit design, the block diagram of the design, and the schematic diagram of the design, the design calculations and considerations. The block diagram of the proposed hybrid inverter system for the residential building is shown in figure 1

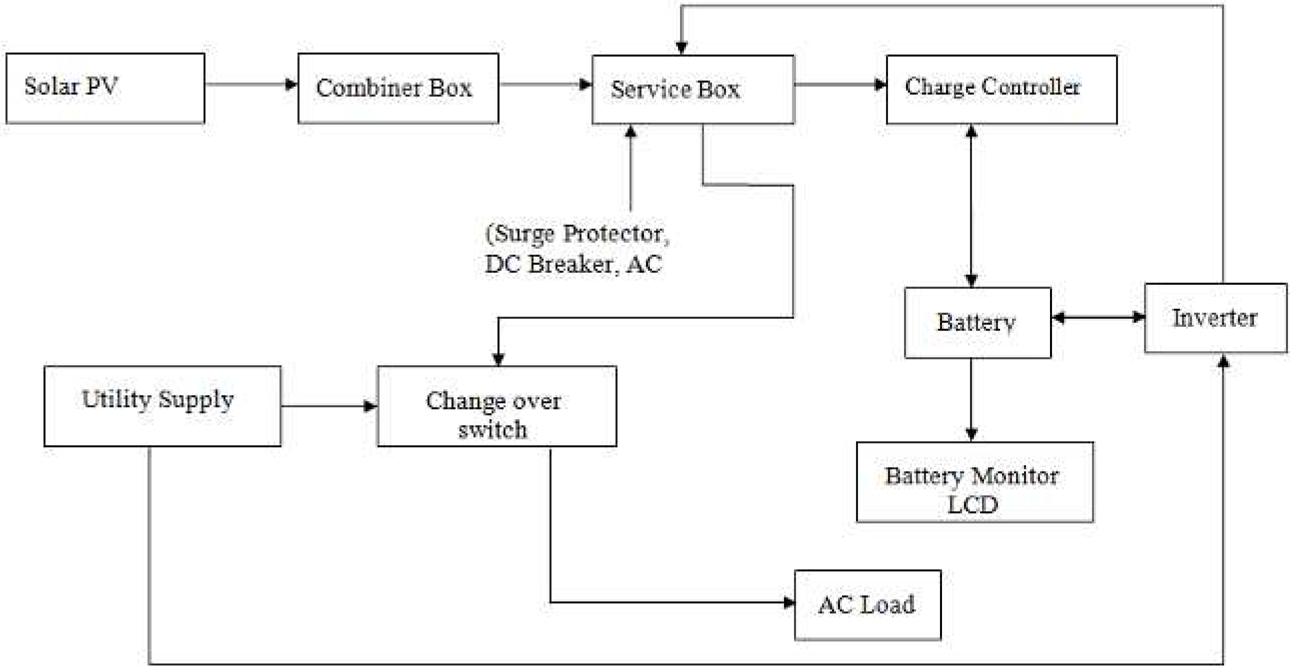

Figure 1: Block Diagram of Hybrid Inverter

A. Load Estimation

Table1: Total Load Demand

S/N	Appliances	Appliance categories	Quantity	Actual load in Watts	Total load in Watts	Operating time (Hours/Day)	Watts-Hour/Day
1	LED Lights	Night Use	300	12	3600	13	46800
2	High Flux LED	Night Use	150	18	2700	13	32400
3	Cell Phone Charger	24 Hours	4	5	20	24	480
4	TV Sets	12 Hours	5	250	1250	12	15000
5	Air-conditioned	14 Hours	5	2984	14920	14	208880
6	Solar Charge Controller	24 Hours	1	10	10	24	240
7	Inverter	24 Hours	1	100	100	24	2400
	Total Load (Watts)				22595		
	Total Watt-Hour Per Day						306200

From table 1 total connected load in watts is 22595W and total watt-hour load per day is 306200Wh/day

For total load of 22595watts, size of inverter would be (22595/0.8) = 28243.75VA, where 0.8 is the power factor. The nearest inverter size to this would be a 30KVA inverter.

B. Estimation of number of PV panels

To calculate the Wattage of the Solar Panels, the method adopted by Moien was used.

$$P_{PV} = \frac{E_d}{PSH \times \eta_{CR} \times \eta_{inv}} (7) \qquad 1$$

Where,

E_d = is the daily energy consumption of the residential building (kwh/day)

η_{CR} = Charge regulator efficiency = 95%

PSH = Average annual peak sunshine hours (PSH) is obtained as 6.2kwh/m^3

η_{inv}= 90%

From equation 1, P_{PV} = 57762.6 Wp

A PV generator with a peak power of 60320Wp will be selected to secure for continuous power availability during grid outage hours and to compensate for cloudy days and all system electrical losses. In addition, increasing the PV peak power will secure for maintaining an appropriate level of state of charge of the battery block. A monocrystalline PV module with 144 cells connected in series and a peak power of 520Wp will be used. In this case, 29 parallel strings, each consists of 4 PV modules connected in series, will constitute the PV generator which has a nominal DC voltage of 192V as shown in Figure 2. This voltage is selected to match with the nominal voltage of the storage battery block.

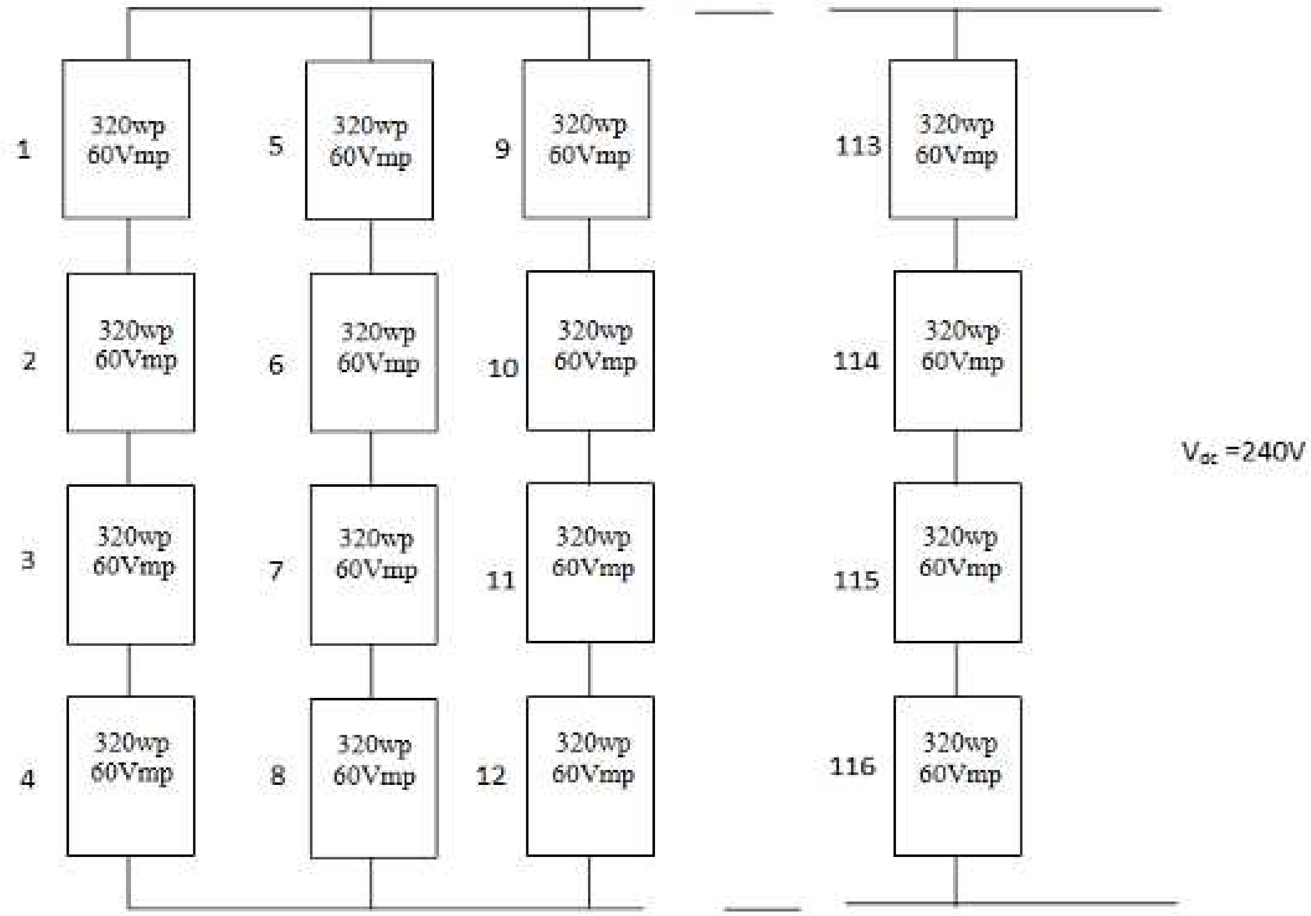

Figure 2: The PV generator rated at 60320Wp /192V

C. Estimation of battery bank

In selecting battery bank within the time frame per day, the formula in equation 2 was used

$$Q = \frac{E \times A}{V \times T \times \eta_{inv} \times \eta_{cable}} \quad (8) \qquad 2$$

Where
Q = Battery capacity, AH
E = Daily energy required, Wh
V = System DC voltage, V
A = Number of days of storage required or Days of autonomy (two days is chosen)
T = Depth of discharge = (usually between 20% to 80%, 80% is chosen)
η_{inv}= Inverter efficiency = 90% (1.0 if there is no inverter)
η_{cable}= Cable efficiency delivering the power from battery to the loads (here it is taken as 95%)
From equation 2, Q = 4664AH

In order to increase the battery storage safety factor and to respect the industry produced norm values, a lead acid block battery cell rated at 6400AH/192V will be selected to constitute the storage system which consists of 2 parallel strings, each consists of 16 cells connected in series to present a DC power source.

D. Cable Selection

When the size and type of cable are well selected, this improves reliability and performance of PV system. That is why cable sizing is a very important step. In this system we used copper wire.

The cables cross sectional area are determined by the following equation:

$$CT = \frac{(L \times I \times 0.04)}{(V \div 20)} \quad (9) \qquad 3$$

Where CT = Cable thickness
L = length of run of cable, 10m
I= system current = 28243.75VA/192 = 147A
V= system voltage, 192V

The cable size or thickness is calculated from equation 1 as, CT = 9.2 mm^2, 10mm^2 will be appropriate.

E. Selection of Charge Controller

To Calculate PV Array Current (Minimum Controller Input Current) PV Array Current = I_{SC} x PV_P x Safety Factor (4) I_{SC} = Module short circuit current = 13.58 amps.

PV_P = PV modules in parallel = 2 no. Safety Factor = 1.25

PV Array Current = 13.58 x 2 x 1.25 = 33.95A Therefore, a 192V/60A charge controller was selected.

RESULTS

The design of 30KVA Hybrid inverter system was carried out in this paper. The design specifications of various components is tabulated as shown in table 2.

Table 2 System components and their specifications

Components	Specifications
Inverter	30KVA/192V
Battery	200AH/12V x 32
Solar panel	520Wp/60V x 116
Cable size	10mm^2
Charge controller	192V/60A

This system is designed by keeping in view of monthly electrical load. Moreover, the design specification of solar system components is determined by performing calculations manually

CONCLUSION

The hybrid solar system design of solar has been done utilizing both solar power and grid supply in line with Nigerian networks. The use MPPT charge controller which is a dc-dc (buck-boost) converter has increased the efficiency of the system and it gives the constant voltage and power to the system. Battery voltage has been kept at 192V for the operation of the system. The supply output was almost constant and the efficiency was kept at 90%. It can be inferred from the above, that hybrid solar system is much suited for those areas where both grid supply and solar irradiation is available.

Plate 3: Solar Installation Final

Plate 4: Battery arrangements

REFERENCES

[1] Ekpenyong, E. E, Bam, M. E and Anyasi, F. I (2012). Design Analysis of a 1. 5kva Hybrid Power Supply for Power Reliability. Published by IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE) ISSN: 2278-1676Volume 3, Issue 3 (Nov. - Dce. 2012), PP 08-19 www.iosrjournals.org

[2] Olasunkanmi I. (2017). Design and Implementation of a Hybrid (Solar-Wind) Power System

[3] Niaz M. H., Ifthekhar A., Sayem M., Asad A M., and Hasan A. (2017). Design And Implementation Of Cost Effective Inverter

[4] Hamidul I., Margaret J., and Sujeeva S. (2015). Life cycle assessment and life cycle cost implication of residential buildings—A review. Published: Elsevier

[5] Marias G. G. (2020). Design of A Small Scale Off-Grid Solar Energy Plant. Available at NOVIA University of applied sciences YRKESHOGSKOLAN

[6] Ogbekwe T. C. (2010). 3kva Hybrid Power Supply System for 18-Unit Computer Laboratory. Project report carried out in Chukwuemeka Odumegwu Ojukwu University, Department Of Electrical/Electronic Engineering.

[7] Moien A. O. and Marwan M. M. (2019). Design and Simulation of a PV System Operating in Grid-Connected and Stand-Alone Modes for Areas of Daily Grid Blackouts. An-Najah National University, Electrical Eng. Department, Nablus, P. O. Box: 7, West Bank, State of Palestine. International Journal of Photoenergy

[8] Bhatia A. (2022). Design and Sizing of Solar Photovoltaic Systems. Continuing Education and Development, Inc. 22 Stonewall Court Woodcliff Lake, NJ 07677. Available at: info@cedengineering.com

[9] Michael B. (2012). Solar Electricity Handbook: A simple practical guide to solar energy-designing and installing photovoltaic solar electric systems: Published by Greenstream Publishing, Sixth Edition