Review on Design & Simulation of Multi Stage Converter for Hybrid Wind-PV System

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ABSTRACT

Energy plays an important role in all types of development, including economic development. The thermal power stations are causing pollution which severely affects mankind and nature. This paper presents a new system configuration of the front-end rectifier stage for a hybrid wind-photovoltaic energy system. This configuration allows the two sources to supply the load separately or simultaneously together depending on the availability of the energy sources. Hybrid energy system needs the boost converter to be designed to connect with wind and solar energy systems separately. The hybrid system is also designed using Cuk-SEPIC fused converter and the performances are analyzed.. Simulation results are given to highlight the merits of the proposed circuit. To fulfill the challenging demands of the growing grid, new inverters are needed. In this project a reduced switch modular inverter design is detailed.

Keywords: *Hybrid system, Cuk - Sepic converter, modular inverter*

1. Introduction

The world total energy annual consumption generally increases, with the vast majority of energy being produced by fossil fuels such as coal, oil and natural gas. In 2002 fossil fuels provided the three quarters of the total. With the current energy consumption rate, proven coal reserves should last for about 200 years, oil for approximately 40 years and natural gas for around 60 years. With constantly increasing development, diminishing fossil fuel resources and related environmental problems (e.g. emissions), sustainable development and the manner in which energy is produced and consumed is reconsidered. Renewable energy , i.e., energy generated from solar, wind, biomass, geo-thermal, hydropower and ocean resources, could increase the diversity of energy supplies and offer "clean"-environmental friendly energy. Although wind and solar energy sources are significantly less productive compared to fossil fuels, the use of photovoltaic (PV) cells and wind turbines has increased rapidly during the last years, especially in developed countries. Photovoltaic (PV) cells are electronic devices that are based on semiconductor technology and can produce an electric current directly from sunlight. The best silicon PV modules currently commercially available have an efficiency of over 18%, and it is expected that in about 10 years' time module efficiencies may rise to 25%.

Wind power is basically electricity produced by a generator, which is driven by a turbine according to flowing air's aerodynamics, and is one of the fastest growing renewable energy technologies around the world. PV modules and wind turbines are now widely used in developed countries to produce electrical power in locations where it might be inconvenient or expensive to use conventional grid supplies. However, when electricity grids are non-existent or rudimentary, all forms of energy can prove very expensive. In such cases, solar and wind

energy can be highly competitive. The fact that natural energy resources are intermittent and storage batteries are expensive, has led to the utilization of so-called hybrid renewable energy systems. Any power system that incorporates two or more of the following is referred to as a hybrid power system: PV panels, wind turbines, or diesel, propane, gasoline generators. For small loads, the most common combinations are PV-wind hybrid system. PV and wind is a good match, because inland wind speeds tend to be lower in summer, when solar energy can compensate, and higher in winter, when sunshine falls to very low levels.

In this paper, a PV-wind hybrid system is presented able to supply electricity to a private house, farm house or a small company or an apartment, with electrical power depending on the site's needs.

2. .Literature Review

Yerra Sreenivasa Rao, A. Jaya Laxmi And Mostafa Kazeminehad [1] proposes a hybrid energy conversion system combing photovoltaic and wind turbine as a small scale alternative source of electrical energy where conventional generation is not practical. The hybrid system consists of photovoltaic panels, wind turbines and storage batteries. Two individual dc-dc boost converters are used to control the power flow to the load. A simple and cost effective control with dc-dc converter is used for maximum power point tracking (mppt) and hence maximum power is extracted from the o turbine and the photo voltaic array.

A.Naveen Kumar , Shaik Ansar, Ch.V Ganesh [2] presents a new multi-input cuk-sepic rectifier stage for hybrid wind/solar energy systems has been presented. The features of this circuit are: 1) additional input filters are not necessary to filter out high frequency harmonics; 2) both renewable sources can be stepped up/down (supports wide ranges of pv and wind input); 3) mppt can be realized for each source; 4) individual and simultaneous operation is supported. Simulation results have been presented to verify. Here he represented a sinusoidal pulse width modulation for the inverter .it will provide a better output results for the load.

Sandeep Kumar1, Vijay Kumar Garg [3] published paper on a hybrid model of solar wind power generation system this paper deals with the detailed of a hybrid model of a solar / wind in simulink, which is using battery as its storage system. The simulation includes all realistic components of the system, in this system power delivered by the combine system component is compared with each other and various conclusions are drawn.

Ghassan halasa1, johnson a. Asumadu [4] presented paper on wind-solar hybrid electrical power production to support national grid: case study – jordan the paper presents the next generation of power energy systems using solar- and wind-energy systems for the country of jordan. The opportunity of a large wind and solar hybrid power production is being explored. The paper discusses different power electronics circuits and control methods to link the renewable energy to the national grid. This paper also looks at some of the modern power electronics converters and electrical generators, which have improved significantly solar and wind energy technologies.

I.A. Adejumobi, S.G. Oyagbinrin, F. G. Akinboro & m.b. Olajide [5] published paper on hybrid solar and wind power: An essential for information communication technology infrastructure and people in rural communities this paper tells us that one of the primary needs for socio-economic development in any nation in the world is the provision of reliable electricity supply systems. This work is a development of an indigenous technology hybrid solar -wind power system that harnesses the renewable energies in sun and wind to generate electricity.

First report of the committee on non-conventional energy to power rural telephony [6] tells us that the problem of poor electricity supply is experienced at the telecom service providers installations as well as at the customers' premises. At the telecom installations, the problem is tackled by using diesel generators. These generators, however, entail transportation and storage of diesel which is a major problem in rural/remote area, besides the problem of noise pollution emanating from the generators. At customers' premises the electricity supply problem is partially mitigated by using battery inverters or dc-dc converters. The battery however remains only partially charged if the electric supply is too unreliable

U ur fesl, raif bayir, mahmut ozer [7] gave paper on design and implementation of a domestic solar-wind hybrid energy system in this study, "a domestic type solar-wind hybrid system design and application" was implemented. In the implemented system, control card in which the software. Real time control of the inputs and outputs was carried out by 3 current sensors and 3 voltage sensors in the system. Maximum power point tracking system used in the mppt provided optimum benefit from the solar energy

Neeraj tiwari, d. Bhagwan [8] das presented paper on mppt controller for photo voltaic systems using cuk dc/dc convertor this paper introduces an approach to design cuk conver-ter for photovoltaic system, the output of cuk converter is track and measure continuously by varying pulse width modulating (pwm) signal. This signal is used to con-trol the duty cycle of the cuk converter. Cuk convertor can step up or step down the voltage according to application, though cuk converter has an inverted output but with suitable connection and also a converter with zero ripples, it can be used successfully.

Gregory sharp prepared a project [9] on sepic converter design and operation the purpose of this project was to design and optimize a sepic dc/dc converter . The sepic converter allows a range of dc voltage to be adjusted to maintain a constant voltage output. This project also goes into detail about how to control the output of the converter with either a potentiometer or feedback to show how it can be implemented in a circuit. From this project, one learns dc-dc converter optimization and control.

J.b.v. Subrahmanyam p. Alluvada bandana k. Bhanupriya c. Shashidhar [10]gives paper on renewable energy systems: development and Perspectives of a hybrid solar-wind system the key element of the concept presented in this paper is That two or more renewable power sources can be connected to A power grid with complex electrical interactions. The use of solar and wind hybrid power generation is an Especially vivid and relevant choice for students of electrical Technology as these are power sources of growing technological, political, and economic importance

abdul fathah [11] submitted thesis on design of a boost converter the switching mode power supply market is flourishing quickly in today's world. This thesis is proposed to provide the designer with a method of boosting dc voltage from 5 volts to 15 volts, by using a boost converter designed specifically for this task.

E. M. Natsheh, *Member*, *IEEE*, A. Albarbar, Member, IEE, and J. Yazdani, Member, IEEE[12] gives paper on "Modeling and Control for Smart Grid Integrationof Solar/Wind Energy Conversion System" In this paper a novel model of smart grid-connectedPV/WT hybrid system is developed. It comprises photovoltaic array, wind turbine, asynchronous (induction) generator, controller and converters. The model is implemented using MATLAB/SIMULINK software package.

V. Saranya, M. Rekha, N. Gokulnath[13]

"Performance of Bidirectional Chopper and Multi-Operational Inverter with Hybrid Energy System" In this paper a power electronic interface circuit is proposed for application of battery electric vehicle, the battery is been charged by using a Photovoltaic cell and a Wind Energy Conversion System. The power flow in the battery vehicles is managed by implementing the power electronic interfaces.

j.b.v. Subrahmanyam, p.k. Sahoo and madhukar reddy [14] gives paper on local pv wind hybrid systems development for supplying electricity to industry.The proposed set-up consists of a photo-voltaic solar-cell array, a mast mounted wind generator, lead-acid storage batteries, an inverter unit to convert dc power to ac power, electrical lighting loads and electrical heating loads, several fuse and junction boxes and associated wiring, and test instruments for measuring voltages, currents, power factors, and harmonic contamination data throughout the system.

S. Ramkumar, V. Sumathi [15] presents paper on Implementation of Reduced Switch Modular Inverter for Hybrid of Solar Photovoltaic and Wind Energy System .To fulfill the challenging demands of the growing grid, new concepts of the inverters are needed. In this project a reduced switch modular inverter design is detailed. A reduced switch modular inverter design is presented for a modern power system which inputs power from both AC and DC Renewable Sources

Caddet centre [16] for renewable energy gave a project on a pv-wind hybrid system on bullerö island, sweden. This report give idea about the pv-wind power installation meets almost all the island's energy demand less than half the cost of installing grid connection. Thus this method is a cost-effective use of renewable energy in a remote situation.

jeff falin [17] tells about designing dc/dc converters based on sepic topology the single-ended primary-inductance converter (sepic) is a dc/dc-converter topology that provides a positiveRegulated output voltage from an input voltage that varies from above to below the output voltage..

C.A. Nwosu, m.eng. And m.u. Agu [18] presented a paper about power and energy balance in wind-solar hybrid power system. In this paper, power and energy balance in a wind-solar hybrid power system having battery and combined heat and power subunits as backups, is presented. A case study for winter and summer seasons are conducted in an urban city in the netherlands.

3. Proposed Wind Energy and Solar Or PV system

3.1 PV cell PV cell is basically a semiconductor *p-n* junction-based photodiode. This semiconductor photodiode generates electrical power when exposed to light. The power produced by a single PV cell is not enough Therefore, by connecting PV cells in series, higher voltage can be obtained and in parallel higher current can be obtained consequently higher power. Generally, a combined series and parallel connection of PV cells is known as a module. Mostly, commercial modules consist of 36 or 72 cells. The modules consist of transparent front side, encapsulated PV cells, and back side. The front side material is usually made up of low-iron and tempered glass.A PV array (system) is an interconnection of modules which in turn is made up of many PV cells connected in series and parallel. The power produced by a single module is seldom enough for commercial use, so modules are connected to form an array to supply the load.

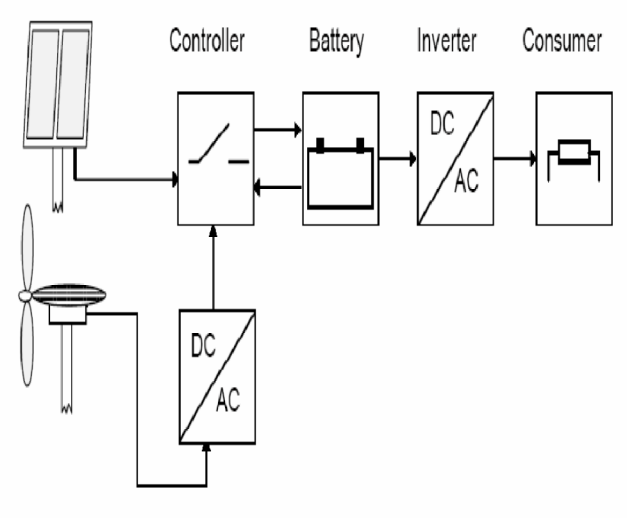

Fig 3.2.1 A typical hybrid energy system

3.2 Wind Power The wind is a renewable energy source, continuously generated or replenished by the forces of nature. Wind Power is energy extracted from the wind, passing through a machine known as the windmill. Electrical energy can be generated from the wind energy. This is done by using the energy from wind to run a windmill, which in turn drives a generator to produce electricity. The windmill in this case is usually called a wind turbine. This turbine transforms the wind energy to mechanical energy, which in a generator is converted to electrical power. An integration of wind generator, wind turbine, aero generators is known as a wind energy conversion system (WECS) Component of a wind energy project Modern wind energy systems consist of the following components A tower on which the wind turbine is mounted, A rotor that is turned by the wind ,The nacelle which houses the equipment, including the generator that converts the mechanical energy in the spinning rotor into electricity. The diameter of the area swept by the rotor is also important. The amount of power transferred to a wind turbine is directly proportional to the area swept out by the rotor, to the density of the air, and the cube of the wind speed. A typical hybrid energy system consists of solar and wind energy sources. The principle of an open loop hybrid system of this type is shown in Figure.

The power produced by the wind generators is an AC voltage but have variable amplitude and frequency that can then be transformed into DC to charge the battery. The controller protects the battery from overcharging or deep discharging. As high voltages can be used to reduce system losses, an inverter is normally in traduced to transform the low DC voltage to an AC voltage of 230V of frequency 50 Hz.

The hybrid PV-wind generator system has been designed to supply continuous power of 1.5 kW and should has the following capabilities:

•Maximizes the electric power produced by the PV panels or by the wind generator by detecting and tracking the point of maximum power. Stores the electric energy in lead-acid batteries for a stable repeater operation. Controls the charge and discharge processes of the batteries.Protects wind generator from over speeding by connecting a dummy load to its output. Local solar radiation information: high, low and average values of daily solar radiation calculated over one year.

3.3 Cuk converter

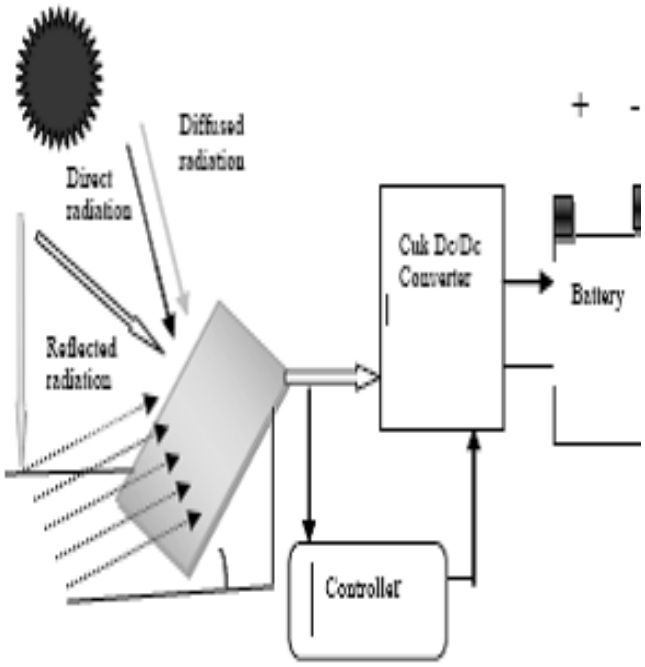

Fig 3.3.1 PV solar system with cuk converter

Many years ago, Dr. Cuk invented the integrated magnetic concept called Dc-transformer, where the sum of Dc fluxes created by currents in the winding of the input inductor and transformer T is equal to Dc flux created by the current in the output inductor winding. .

Hence the Dc fluxes are opposing each other and thus result in a mutual cancellation of the Dc fluxes Cuk converter has several advantages over the buck converter. One of them cuk converter provide capacitive isolation which protects against switch failure. Other advantage is, the input current of the Cúk is continuous, and they can draw a ripple free current from a PV array that is important for efficient Maximum power point tracking (MPPT).

The main applications of this circuit are in regulated dc power supplies, where a negative polarity output may be desired with respect to the common terminals of the input voltage and the the average output is either higher or lower than the dc input voltage.The typical schematic circuit for the Cuk Converter is as shown in Fig.. The capacitor acts as a primary means to store and transfer the power from input to output. The voltage is always greater than either input or output voltage. The average output to input relations are similar to that of a buck-boost converter circuit

The output voltage is controlled by controlling the switch-duty cycle. The ratio of output voltage to input voltage is given by:

Where, Vo and Vin are the output and input voltages, respectively. The term Io and Iin are the output and input currents, respectively. The term D is the duty ratio. This shows the output voltage to be hgher or lower than the input voltage, based on the duty-ratio D

- **SEPIC Converter**

SEPIC is a DC to DC converter and is capable of operating in either step up or step down mode and widely used in battery operated equipment by varying duty cycle of gate signal of MOSFET. We can step up or step down voltage .For duty cycle above 0.5 it will step up and below 0.5, it will step down the voltage to required value. Various conversion topologies like buck, boost, buck-boost are used to step up or step down voltage. Some limitation like pulsating input and output current, inverted output voltage, in case of buck converter floating switch make it unreliable for different application. So it is not easy for conventional power converter design to maintain high efficiency especially when it step or step down voltage. All these characteristics are obtained in SEPIC DC to DC power conversion. Different designs are used using active and passive components. Non- inverted output ,low equivalent series resistance(ESR) of coupling capacitor minimize ripple and prevent heat built up which make it reliable for wide range of operation.

- **Basics of sepic converter**

The basic converter we see in our day to-day life is buck converter. It is so called, because it only step down the input voltage .the output is given by

Vo=DVs

Where Vo=output voltage

Vin =input voltage

D=duty cycle

By interchanging input and output we get boost converter .which only step up voltage, hence its name boost. The output is always greater than input, but main problem is to get step up and step down voltage from a single device depending on output. We can use two cascaded converters (a buck and a boost).but for this two separate controller and separate switch are required. So it is not the good solution .Buck-boost converter can give required output but here output is inverting .These converters have more component stresses, component sizes and lesser efficiency. To reduce the losses caused by high voltages, a circuit with buck-boost conversion characteristics, small energy storage element required and smaller inductor size is desired .but inductor should not be so less ,such that ripple current is high.

Thus, the optimum converter however should have low component stresses, low energy storage requirements and size and efficiency performance comparable to the boost or the buck converter. One converter that provided required output is the SEPIC (single ended primary inductor converter) converter. By varying duty cycle of gate signal of MOSFET we can vary the output. If duty cycle is greater than 50%, it will step up.so it is called as boost converter. if duty cycle is below 50% it will step down the voltage and it operate as buck converter. Another advantage of this converter is it provides a positive regulated output voltage from an input voltage that varies from above to below the output voltage. It function as both like a buck and boost converter, the SEPIC also has minimal active components, a simple controller that provide low noise operation.

Operation

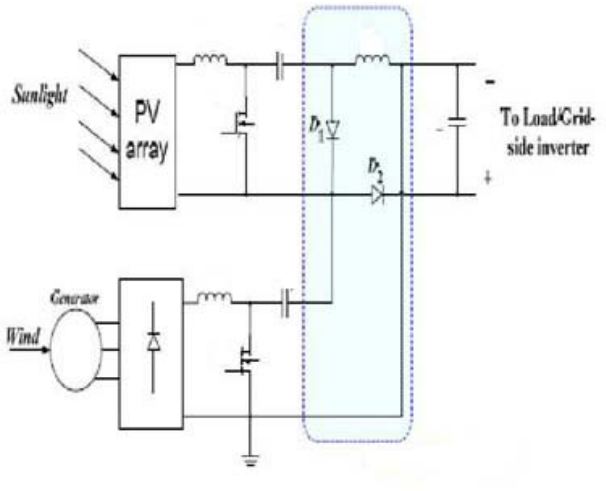

Fig 3.3.2Proposed rectifier stage for a Hybrid wind/PV system

. A proposed hybrid wind-solar energy system is shown in Figure, where one of the inputs is connected to the output of the PV array and the other input connected to the output of a generator.

The fusion of the two converters is achieved by reconfiguring the two existing diode from each converter and the shared utilization of the Cuk output inductor by the SEPIC converter

3.4 DC Link Module

The power from all input sources is summed in the dc link module and injected into the grid by one common inverter. At any time, power flow through the entire system should remain balanced. The dc link module plays an important role in maintaining the power flow balance in this multi-input system. As illustrated in Figure , the boost choppers are connected to a common inverter via the dc link capacitors maintain the input-output power balance and to decouple the front-end converters and the grid inverter which provide a buffer between the instantaneous output power of the boost choppers and the

input power of the inverter. It can be found that by applying a constant dc link voltage control strategy, the power injecting into the grid can track rapidly the input power of the multi-input sources through this simple control system.

3.5 Inverters

To fulfill the challenging demands of the growing grid, new concepts of the inverters are needed. In this project a reduced switch modular inverter design is detailed. A reduced switch modular inverter design is

inductor in those converters provides the function filter reducing harmonics.

3.6 Modular inverter with reduced switch

Conventional three phase inverter system structures are fixed in size and function and offer only limited flexibility demands and to be more versatile in production and development, a new standardized system concept with modular structure is needed. Modularity basically means a segmentation of the complex structures into functional groups. In this way the main components of an inverter structure can be subdivided and the resulting modules can be treated as standalone systems. By use of standardized interfaces these separated modules can be scaled independently. The result is an inverter system that is completely adaptive regarding size, components, configuration and the operating control. The system is flexible to be quickly adapted and optimized for any application demands. Modularity or modular design is the subdivision of a complex system into smaller units (modules) with basic functionalities. These modules can then be used in different systems with multiple functionalities. A module pool keeps different discrete modules that can perform defined discrete tasks or functions. To connect any modules in a free selectable order and topology, standardized interfaces have to be defined to react on linked neighbor modules and hand over information to them. Production costs are reduced by presented for a modern power system which inputs power from both AC and DC Renewable Sources. The modular inverter is the combination of both three phase inverter and three phase inverter with the neutral point and it supports both symmetrical and asymmetrical loads. Power Electronics Inverter is the key component to couple the two different renewable energy sources such like solar and wind. The converter is the combination of Cuk – SEPIC converters, the input from the source can be either buck or boost or stabilized at a particular value, the completely independent manufacturing of the various modules. Furthermore, modular design offers additional benefits such as augmentation and exclusion. An existing system can be enlarged, updated, modified or pared down in functionality by adding or excluding new sub functional modules. The basic principle of modularity can be applied to the two main fields of inverter design, the hardware and the software design. Although these design fields are functional closely related to each other, they can be more or less decoupled in design by standardized interfaces. In the underlying project, the modular approach has been applied to the design of an exemplary inverter system the applied modularity will now be detailed. At this point it has to be mentioned that the level and depth of modular design applied to inverters, but also to any other system, always depends on the product range of the manufacturer and the applications to be covered by the designed systems. The more complex a system is and the more functions it has to perform, the higher the level of modularity should be. The characteristic of the inverter load regarding the symmetry is one of the main influencing factors of the desired power electronic inverter topology

Conclusions

From the above results we can find out that hybrid model of solar and wind energy can full fill the load demand wind energy support the solar energy to full fill load

demand. Through this system we can supply the energy rural area where the sufficient energy cannot produce. Using these technical solutions the electrical energy supply can be resolved for small farms and houses sited in this remote area. Analysing the meteorological data we can obtain a favourite solution for the applicability of the green energy sources in this proposed application. We can use small optimal storage capacity. Because into large storage the cost is increased .Through this system we can decrease the unit rate of energy and reduce the pollution

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