SEPIC CONVERTER BASED HYBRID ENERGY MANAGEMENT SYSTEM

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Abstract-

Renewable energy technologies offers clean, abundant energy gathered from self-renewing resources such as the sun, wind etc. As the power demand increases, power failure also increases. So, renewable energy sources can be used to provide constant loads. A converter topology for hybrid wind/photovoltaic energy system is proposed. Hybridizing solar and wind power sources provide a realistic form of power generation. Renewable energies have advantages of zero fuel cost and reduced environmental impacts.This project proposes a SEPIC converter topology for the hybrid power sources.

Two inputs, one from wind energy and another from solar PV panel are given to the converter and maximum power is extracted by using fuzzy logic maximum power point tracking method. This configuration allows the two sources to supply the load separately or simultaneously depending on the availability of the energy sources. The output is given to inverter which converts dc to ac and then applied load. This hybrid energy is given to the three phase inverter. It will convert that DC voltage into AC voltage. This AC voltage is given to the load. The sinusoidal PWM technique is applied to the inverter to control the output voltage and the PI controller compensates reactive power in the grid. Simulation is carried out in MATLAB 2013a / SIMULINK.

Index terms –Renewable energy, Solar, PMSG Wind, Fuzzy, controller, P&O.

I. INTRODUCTION

Renewable energy sources (RES) such as Solar, Wind, Geothermal, Tidal, Hydro etc. are inexhaustible by nature. The RES have been found promising towards building sustainable and eco-friendly power generation. Due to the limitation of conventional resources of fossil fuels, it has compelled the evolution of hybrid power system. Therefore, new ways to balance the load demand is by integrating RES into the system. Hybrid system enables the incorporation of renewable energy sources and transversals the dependency on fossil fuels, while sustaining the balance between supply and demand. The significant characteristic of hybrid power system includes, system reliability, operational efficiency [1].

The hybrid power system enables to overcome the limitations in wind and photovoltaic resources since their performance characteristics depends upon the unfavorable changes in environmental conditions. It is probable to endorse that hybrid stand-alone electricity generation systems are usually more reliable and less costly than systems that depend on a single source of energy [2]. On other hand one environmental condition can make one type of RES more profitable than other. For example, Photovoltaic (PV) system is ideal for locations having more solar illumination levels and Wind power system is ideal for locations having better wind flow conditions [3].

For RES especially the variable speed wind energy conversion systems, Permanent Magnet Synchronous generator (PMSG) is gaining popularity. PMSG have a loss free rotor, and the power losses are confined to the stator winding and stator core. A multi-pole PMSG connected to power converter can be used as direct driven PMSG in locations with low wind speed there by eliminating the gearbox which adds weight, losses, cost and maintenance [4]. A gearless construction of wind conversion system represents an efficient and reliable wind power conversion system. In a PV system, a solar cell alone can produce power of 1 to 2 watt [5]. The solar cell is modeled by two diode model [6]. The solar cells are connected in series and parallel to form a PV panel or module. The PV modules are connected in series and parallel to form a PV array in order to generate appropriate amount of power.

Thus a PV system consisting of PV array, Maximum Power Point Tracking (MPPT) boost converters, and Wind power system consisting of wind turbine, PMSG, rectifier and MPPT boost converter is integrated into Solar Wind hybrid power system (SWHPS). The efficiency and reliability of the SWHPS mainly depends upon the control strategy of the MPPT boost converter. The solar and wind power generation cannot operate at Maximum power point (MPP) without proper control logic in the MPPT boost converter. If the MPP is not tracked by the controller the power losses will occur in the system and in spite of wind and solar power availability, the output voltage of the hybrid system will not boost up to the required value [7]. The output voltage of the PV and Wind power generation are quite low as compared with the desired operating level. So, this output voltage is brought to desired operating value of 220V using Boostconverter with MPPT controller at each source.

The control logic of the MPPT controlled boost converter for the Wind power generation and PV based generation areselected on the basis of ease of implementation and robustness of the Hill Climb Search (HCS) and Perturb & Observe (P&O) algorithm respectively. This paper deals with the simulation and control of (PV/wind) hybrid systems including energy storage battery connected to the AC load. Study of modeling and simulation on the entire PV/wind/battery hybrid system is carried out under Matlab/Simulink environment.

II.EXISTING SYSTEM

1. Modeling and Control of Hybrid System

A. Photovoltaic Power System

Fig. 1 shows a simplified scheme of a standalone PV system with DC–DC buck converter. This section is devoted to PV module modeling which is a matrix of elementary cells that are the heart of PV systems. The modeling of PV systems starts from the model of the elementary PV cell that is derived from that of the P–Njunction [8].

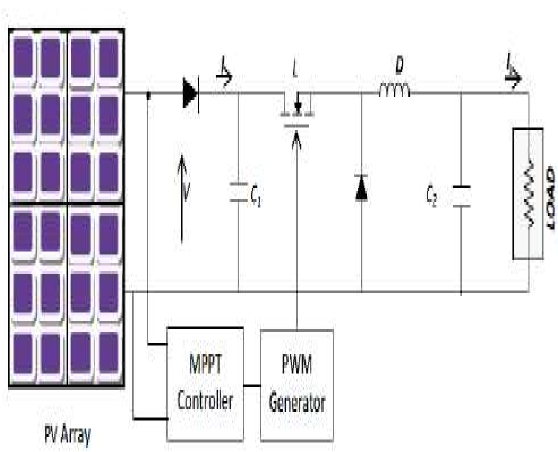


Figure 1. A PV system with a DC–DC buck converter.

B. Ideal photovoltaic cell

The PV cell combines the behavior of either voltage orcurrent sources according to the operating point. This behavior can be obtained by connecting a sunlight-sensitive current source with a P–N junction of a semiconductor material being sensitive to sunlight and temperature. The dot line square in Fig. 2 shows the model of the ideal PV cell. The DC current generated by the PV cell is expressed as follows

$$I = I_{PV,Cell} - I_{s,Cell}\left(e^{\frac{V}{aVt}} - 1\right)$$

The first term in Eq. (1), that is Ipv, cell, is proportional to the irradiance intensity whereas the second term, the diode current, expresses the non-linear relationship between the PV cell current and voltage. A practical PV cell, shown in Fig. 2, includes series and parallel resistances [9]. The series resistance represents the contact resistance of the elements constituting the PV cell while the parallel resistance models the leakage current of the P–N junction. This model is known as the single diode equivalent circuit of the PV cell. The larger number of diodes the equivalent circuit contains, the more accurate is the modeling of the PV cell behavior, however, at the expense of more computation complexity. The single diode model shown in Fig. 2 is adopted for this study, due to its simplicity.

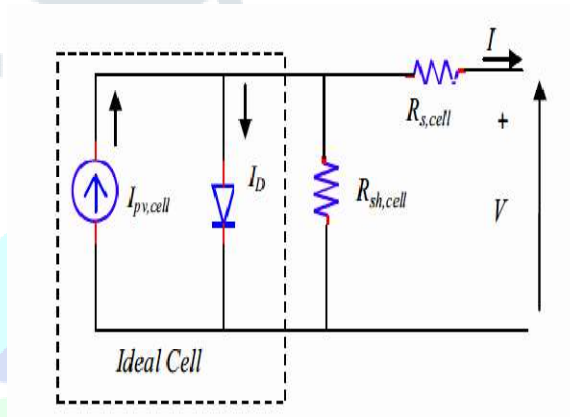


Figure 2. Equivalent circuit of an ideal and practical PV cell.

C. PV module modeling

Commercially photovoltaic devices are available as setsof series and/or parallel-connected PV cells combined into one item, the PV module, to produce higher voltage, current and power, as shown in Fig. 3.

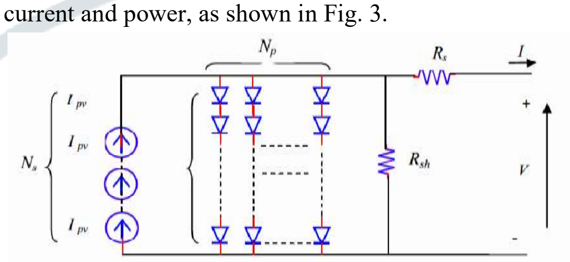


Figure 3. Equivalent circuit of PV module.

D. I–V and P–V characteristics

A PV module can be modeled as a current source that isdependent on the solar irradiance and temperature. Thecomplex relationship between the temperature and irradiation results in a non-linear current–voltage characteristics.

E. Storage Power System

There are three types of battery models reported in the literature, specifically: experimental, electrochemical and electric circuit-based. Experimental and electrochemical models are not well suited to represent cell dynamics for the purpose of state-of-charge (SOC) estimations of battery packs. However, electric circuit-based models can be useful to represent electrical characteristics of batteries. The simplest electric model consists of an ideal voltage source in series with an internal resistance. In this work, a generic battery model suitable for dynamic simulation presented in [14] is considered. This model assumes that the battery is composed of a controlled-voltage source and a series resistance, as shown in Fig.6. This generic battery model considers the SOC as the only state variable [15].

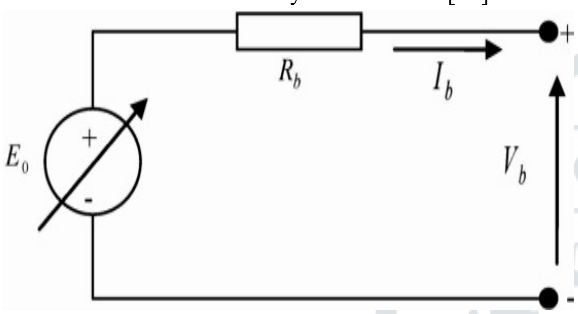


Figure 4. A generic battery model.

2. SYSTEM CONTROL

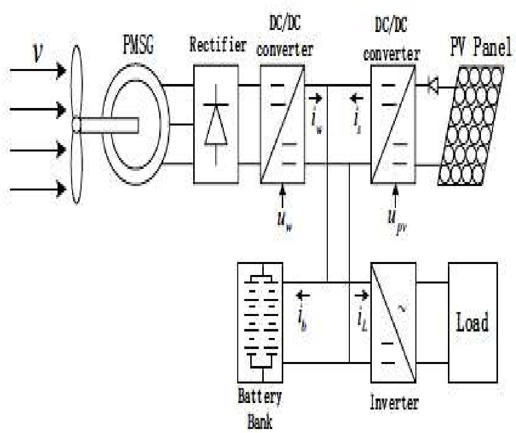


Figure5 . Block diagram of PV-Wind hybrid system

The block diagram of PV-wind hybrid power system is shown in Fig. 8. The hybrid generations consist of Photovoltaic based generation, Wind Power Generation, Battery; Voltage regulated inverter and AC load. A comprehensive mathematical analysis of the Hybrid generation will be discussed in this section.

A. Perturb and Observe MPPT Algorithm for PV array

Perturb and Observe (known as P&O) algorithm,is used in this paper for maximum power tracking of PV array. This method involves perturbation of the voltage, V, and observing the change in power output, P. If the perturbation in one direction increases the power output of the PV array, then the same direction of perturbation is continued. Otherwise, the direction of perturbation is

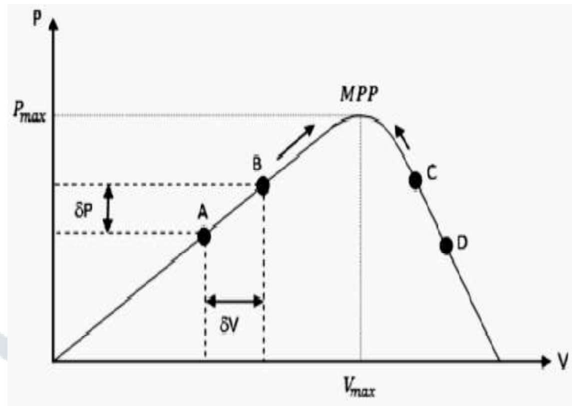


Figure 6. Description of P&O algorithm for MPPT

B. Hill Climb Search MPPT algorithm for wind turbine

The HCS algorithm for MPPT control logic implementation for wind power generation system is shown in Fig. 7.

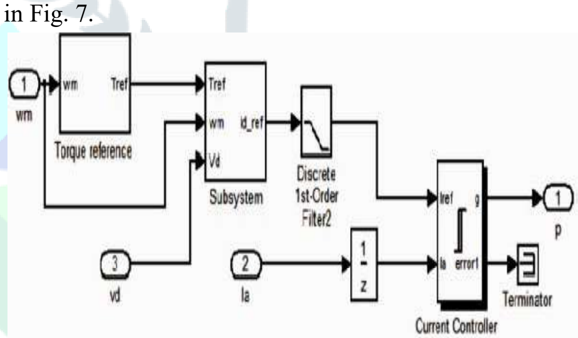


Figure. 7. Sub-system implementation of MPPT control

Using the speed and voltage samples the reference current is calculated. It is compared with the current measured and the error is utilized to compute the duty cycle of the power electronic switch in boost converter which controls the operation of wind power generation at MPP.

C. Voltage regulated inverter design

The inverter plays a key role in the hybrid power generation. The load voltage, frequency is controlled andmaintained constant using inverter in stand-alone operation.The proposed voltage regulated inverter maintains the outputvoltage and frequency constant irrespective of change inwind speed, solar irradiation levels and load condition. Therectified and boosted DC voltage from the PV, wind isapplied as input to the inverter. The schematic diagram ofVoltage regulated inverter is shown in Fig. 8.

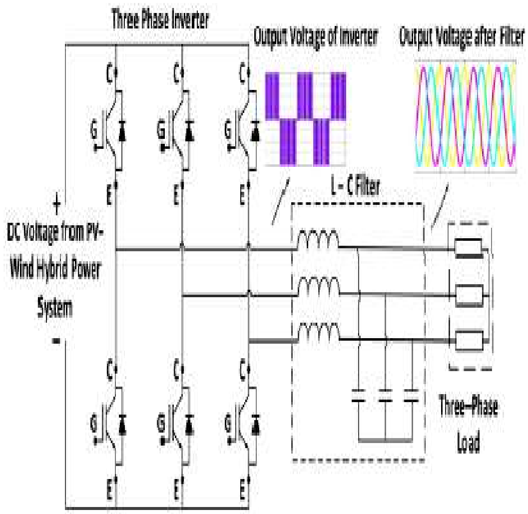


Figure.8. Voltage Regulated inverter

D. PI voltage regulated inverter

The important aspect of voltage regulated inverter is to maintain output voltage and frequency constant. In order to achieve the task a discrete Phase Lock Loop (PLL) with Synchronous Reference Frame (SRF) is implemented to generate control signal of the inverter. The block diagram of the control scheme is shown in Fig. 9. Where VLab, VLbc, VLca are the live voltage of the load

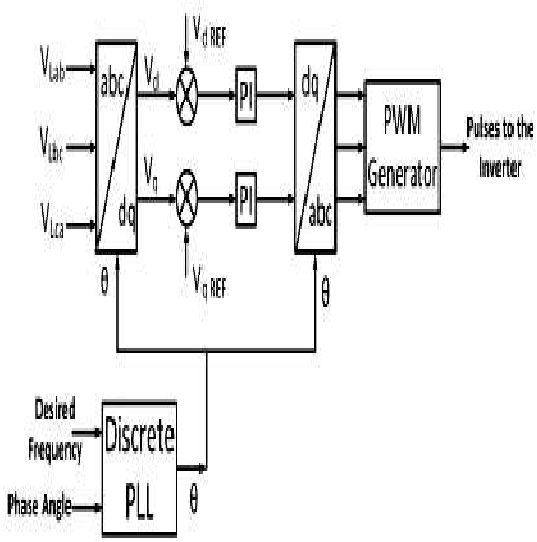


Figure 9. Block diagram of PI voltage regulated inverter

E. fuzzy logic voltage regulated inverter

In the Fuzzy Implementation of mamdani FLC is selected and the inputs of the FLC are error and change in error. They are computed by considering inverter voltage line and have been calculated as output. Fig. 13 indicated the sub-system implementation of algorithm using FLC for voltage regulated inverter from the solar wind generation system.

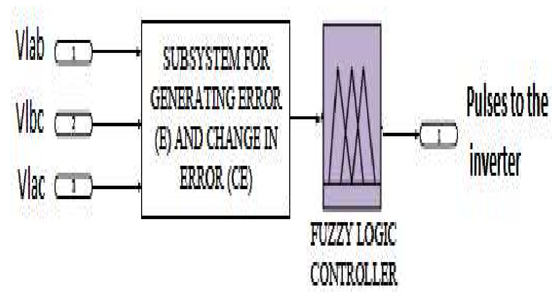


Figure 10. Block diagram of FLC voltage regulated inverter.

III.PROPOSED METHOD

A. Block Diagram

This project proposes a SEPIC converter topology for the hybrid power sources. Two inputs, one from wind energy and another from solar PV panel are given to the converter and maximum power is extracted by using fuzzy logic maximum power point tracking method. This configuration allows the two sources to supply the load separately or simultaneously depending on the availability of the energy sources. The output is given to inverter which converts dc to ac and then applied load.

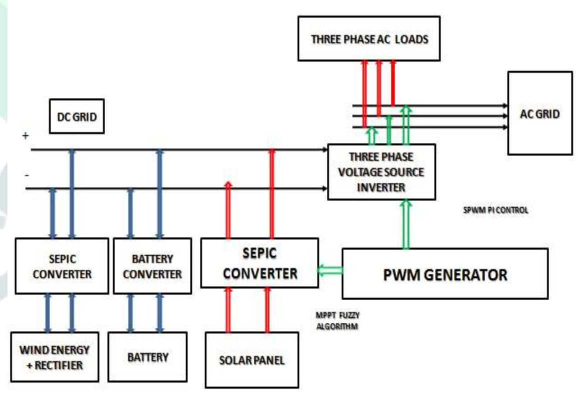


Figure .11 Proposed Block Diagram

Fuzzy Logic is a particular area of concentration in the study of Artificial Intelligence and is based on the value of that information which is neither definitely true nor false. The information which humans use in their everyday lives to base intuitive decisions and apply general rules of thumb can and should be applied to those control situations which demand them. Acquired knowledge can be a powerful weapon to combat the undesired effects of the system response.

In most applications there are some points which lie in the common area. Information which lies within the common area has to be studied, stored, and used to quantify and to classify the data. This allows for smart manipulation of the data structure in order to make inference to a solution. Information which falls in that common area can be ranked, aged, and "best guess" made after evaluation of this "gray" information.Another advantage of Fuzzy Logic controllers is to quantify the input signal in a sometimes "noisy" environment. This noise, which tends to corrupt the integrity of the actual signal, is dealt with through the common sense of the competent operator. Mathematically, the information must be judged and prepared for use in decision making. If an operator took the time to plot the process information on an X-Y coordinate system, the operator could visually apply a curve fit to the data and come up with a fairly accurate generic representation

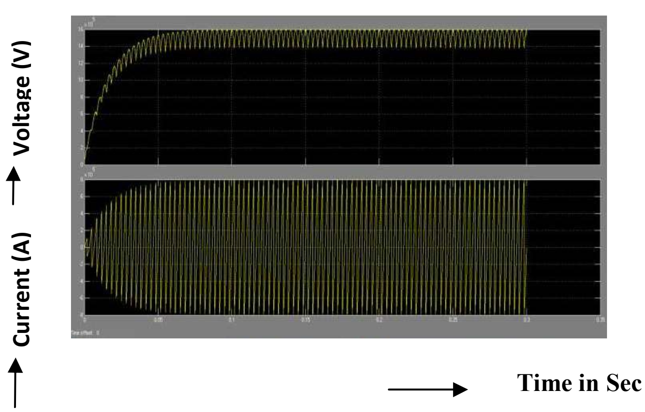
Mathematically, fitting a curve of lower order would produce a fairly inaccurate representation. Therefore, a higher order curve fit would be appropriate to accommodate the noisy signal. Fuzzy Logic attempts to emulate what the human response would be and apply the most intelligent fit to the data. Conventional computing is based on Boolean logic, meaning everything is represented as either zero or one. In some situations this leads to oversimplification and inadequate results. Fuzzy logic controllers, and by extension, fuzzy control, seeks to deal with complexity by creating heuristics that align more closely with human perception of problems.

Fuzzy logic provides a way of dealing with imprecision and nonlinearity in complex control situations. Inputs are passed to an "inference engine" where human or experienced-based rules are applied to produce an output.

IV SIMULATION RESULTS

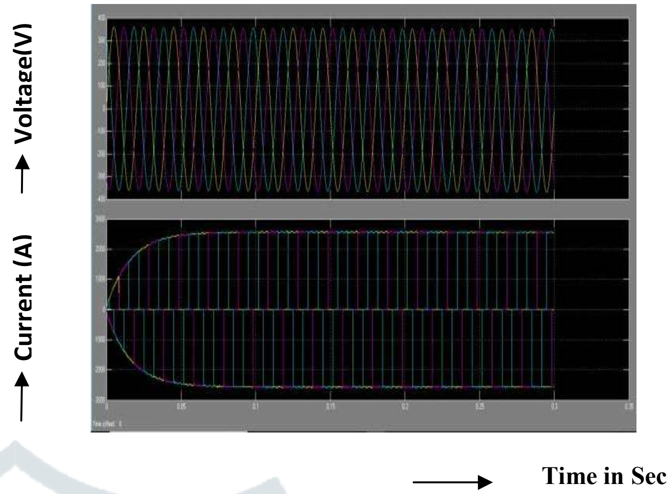
4.1 EXISTING SYSTEM

Wind voltage and current waveform



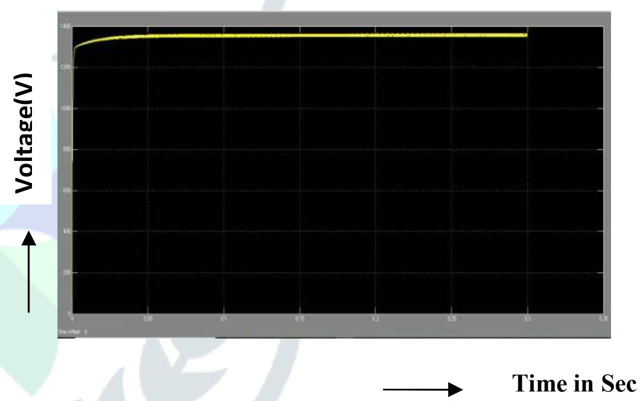
The above figure represents the wind voltage and current of the system.

MPPT Voltage and current



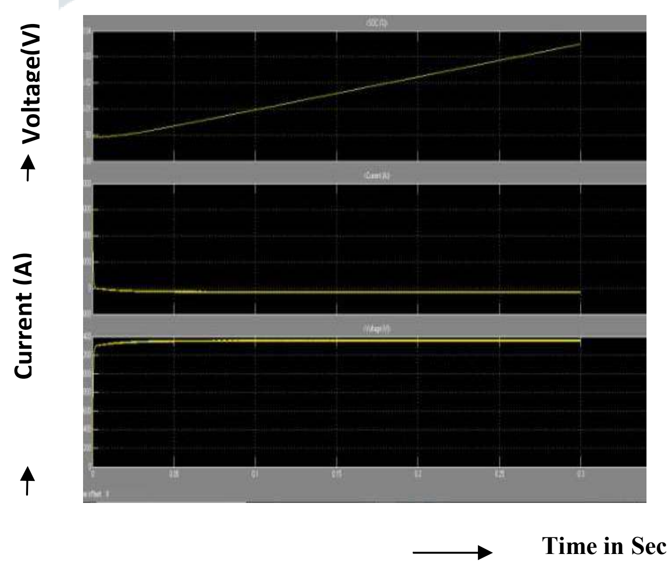
The above figure represents the MMPT voltage and current of the system.

Subsystem voltage



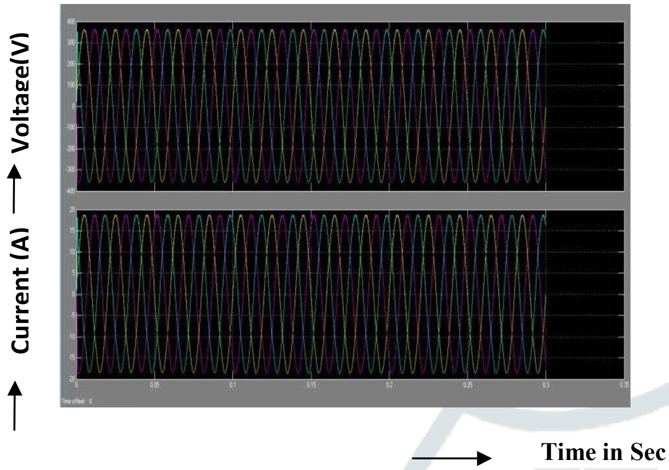
The above figure represents the subsystem voltage of the system.

PI Controller output



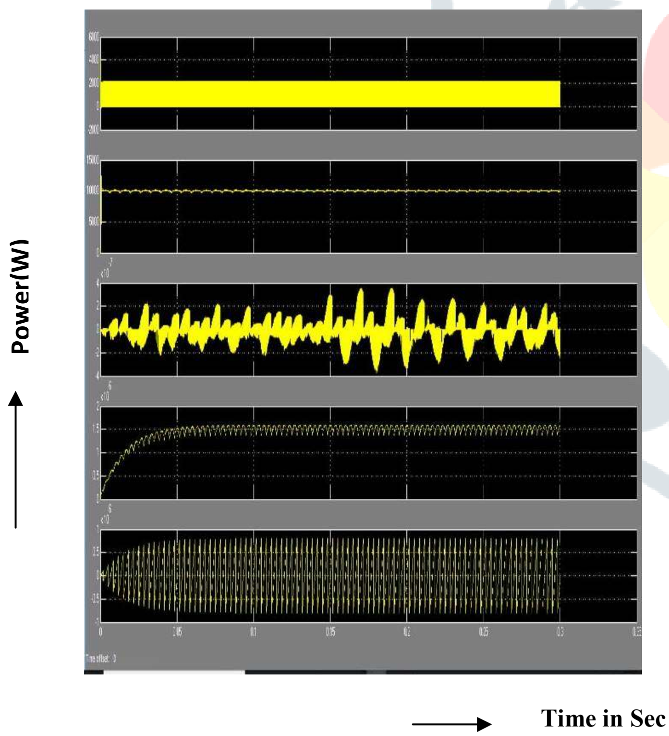
The above figure represents the PI controller output of the system.

Three phase voltage and current



The above figure represents the three phase voltage and current.

Power outputs

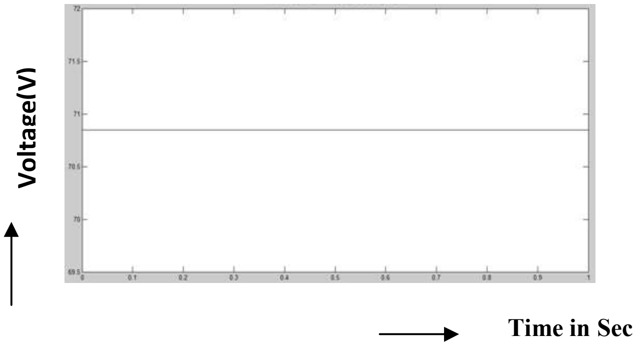


The above figure represents power output of the system.

4.2 PROPOSED METHOD

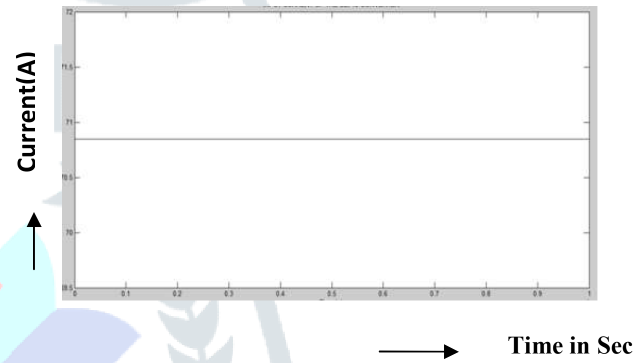
The propsoed results simulated based on sourse code. The corresponding results at diffent points from the proposed simulink model shown below.

Input voltage wave form for SEPIC converter



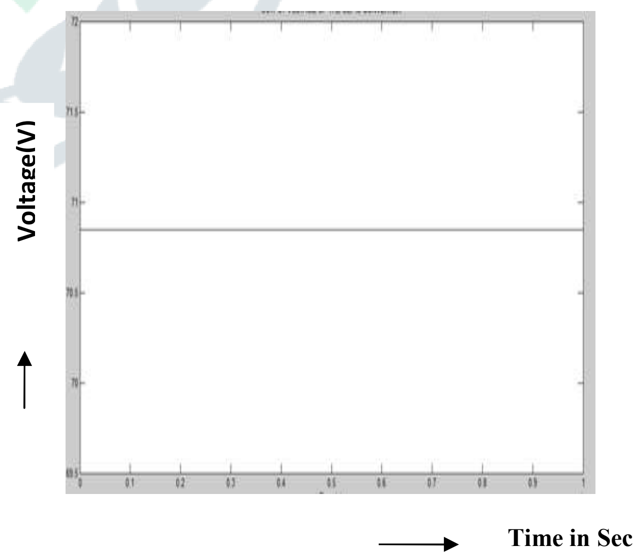
The above figure represents the input voltage of the SEPIC converter.

Input current wave form SEPIC converter



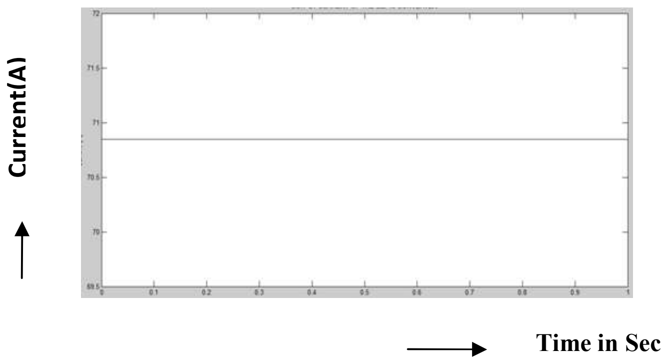
The above figure represents the input current of the SEPIC converter.

Output voltage wave form SEPIC Converter



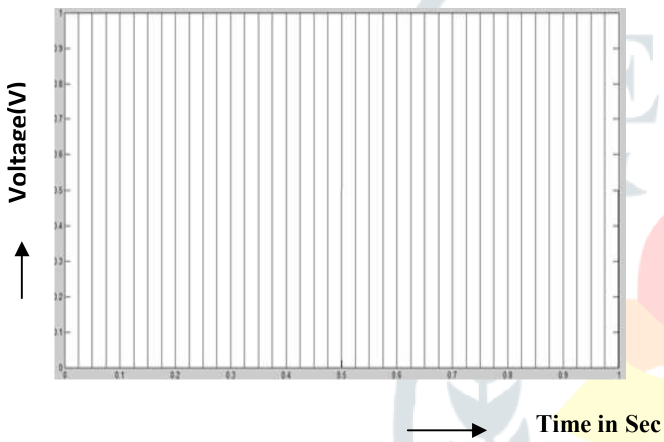
The above figure represents the output voltage of the SEPIC converter.

Output current waveform of SEPIC converter



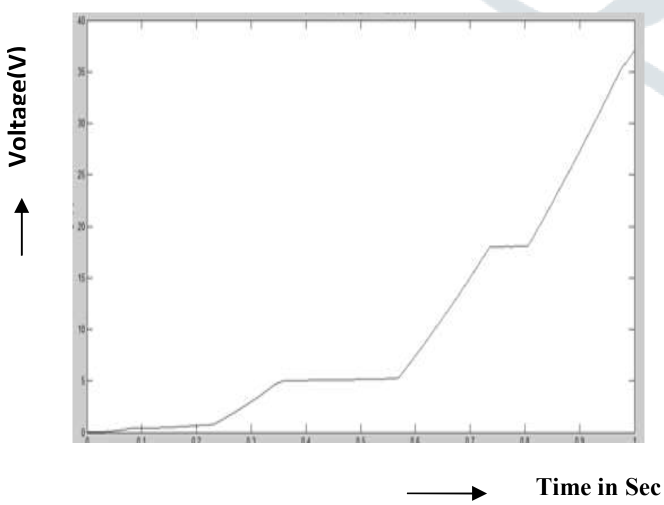
The above figure represents the output current of the SEPIC converter.

PWM Pulses to the SEPIC converter



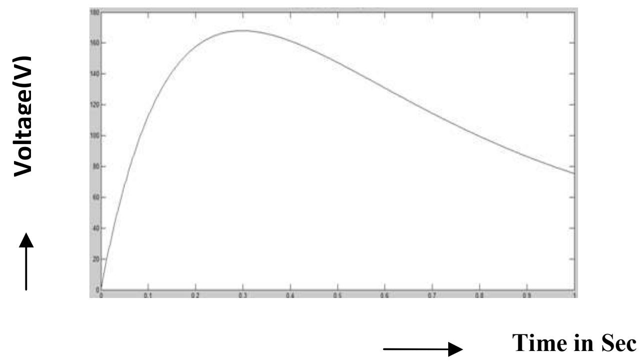
The above figure represents the PWM of pulse to the converter.

Output voltage of the DC Bus



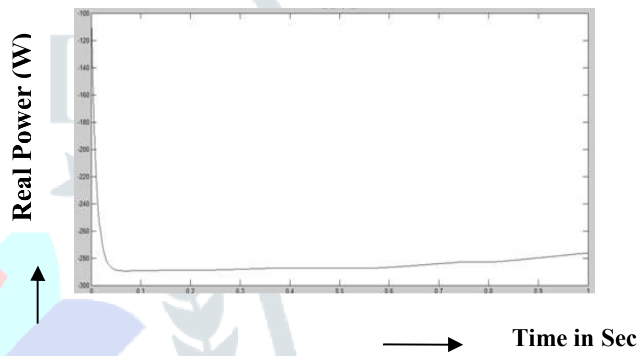
The above figure represents the output voltage of the DC bus.

Battery voltage



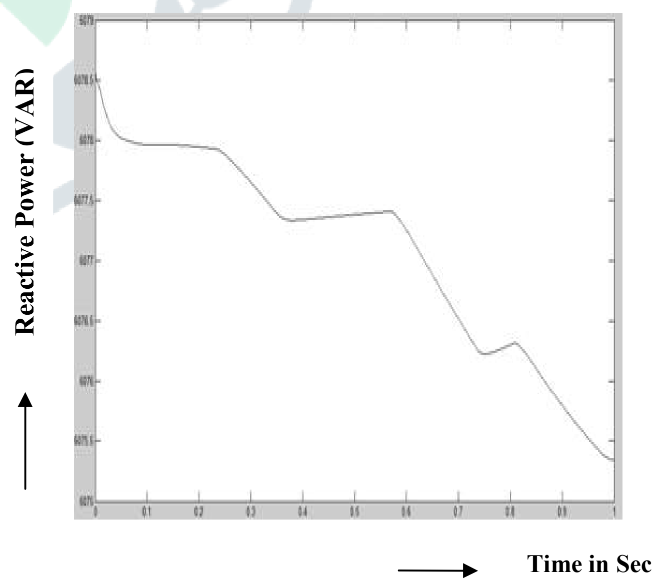
The above figure represents the voltage stored in the battery.

Real power



The above figure represents the real power of the system.

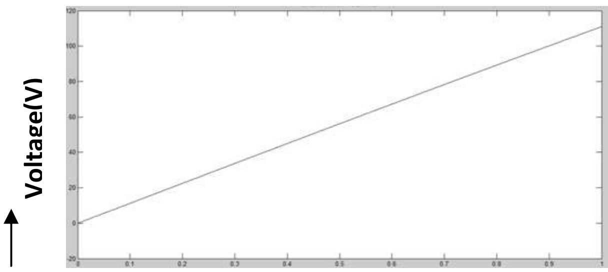
Reactive power



The above figure represents reactive power of the system.

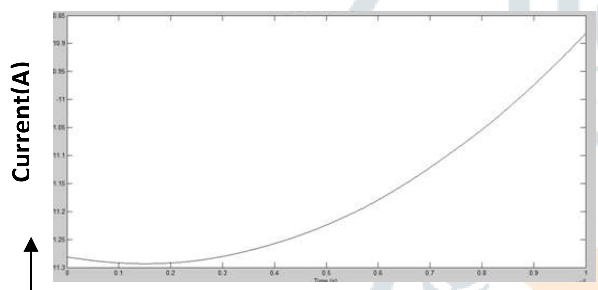
Grid output voltage

The above figure represents the grid output voltage of the system.



The above figure represents the grid output current of the system.

Grid output current



The above figure represents wind output voltage of the system.

4.3 COMPARISON TABLE

S.N	Type of model	Existing method	Proposed method
1	THD (Current)	5.2	1.6
2	THD (Voltage)	2.2	0.8
3	Input Voltage, Current	415V, 15A	415V, 15A
4	MPPT Algorithm	P &O	Fuzzy
5	Reactive Power	2200VA	80VA
6	Voltage Source Inverter Level	Two Level	Two Level
7	Current Control Technique	PLL Based Hysteresis Current	PLL Based Hysteresis Current
8	Voltage Control Technique	PI Controller	PI Controller

The above table shows the threshold values of existing and proposed methods. It shows the proposed threshold value is less than the existing system. Hence by using the fuzzy controller in proposed system reduced the threshold voltage and current. So that improves the performance of operation in proposed system.

VI CONCLUSION

Hence we have conclude that the Two inputs, one from wind energy and another from solar PV panel are given to the converter and maximum power is extracted by using fuzzy logic maximum power point tracking method. This configuration allows the two sources to supply the load separately or simultaneously depending on the availability of the energy sources. The output is given to inverter which converts dc to ac and then applied load. This hybrid energy is given to the three phase inverter. It will convert that DC voltage into AC voltage. The proposed method performance is improved than the existing method.

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