ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com

International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE) Vol. 3, Special Issue 1, February 2017

GRID CONNECTED HYBRID SYSTEM WITH SEPIC CONVERTER AND INVERTER FOR POWER QUALITY COMPENSATION

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***Abstract*—**This paper focuses on design, modeling, simulation and implementation of Single Ended Primary Inductor Converter (SEPIC) based closed loop operation of a novel inverter topology suitable for transformer-less single phase grid connected hybrid systems. 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 paper proposes a multi input 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 (MPPT) method. This configuration allows thetwosourcestosupplytheloadseparatelyorsimultaneouslydependingontheavailabilityoftheenergy sources. The output is given to inverter which converts dc to ac and then applied load. This hybrid energy is given to the Single 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. Simulationis carried out inMATLAB/SIMULINK.

***Key Words*—**SEPIC converter, renewable hybrid energy system, MPPT technique, fuzzy logic controller, PI controller and grid.

I.INTRODUCTION

Due to the critical condition of industrial fuels which include oil, gas and others, the development of renewable energy

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ISSN (PRINT): 2454-9762
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sources is continuously improving. This is the reason why renewable energy sources have become more important these days. Few other reasons include advantages like abundant availability in nature, eco friendly and recyclable. Many renewable energy sources like solar, wind, hydel and tidal are there. Among these renewable sources solar and wind energy are the world's fastest growing energy resources. With no emission of pollutants, energy conversion is done through wind and PV cells. Hybrid generation systems that use more than a single power source can greatly enhance the certainty of load demands all the time. Even higher generating capacities can be achieved by hybrid system. In standalone system we can able to provide fluctuation free output to the load irrespective of weathers condition. To get the energy output of the PV system converted to storage energy, and constant power delivered by the wind turbine, an efficient energy storage mechanism is required, which can be realized by the battery bank.

To maintain the constant output voltage to the grid SEPIC converter is used in this paper. Single Ended Primary Inductor Converter (SEPIC) is a type of DC-DC converter allowing the electrical potential (voltage) at its output to be greater than, less than, or equal to that at its input; the output of the SEPIC is controlled by the duty cycle of the control transistor.The Maximum Power Point Tracking technique is used in this paper to extract maximum power from the solar panel. Maximum power point tracing (MPPT) system is an electronic control system that can be able to coerce the maximum power from a PV system. It does not involve a single mechanical component that results in the movement of the modules changing their direction and make them face straight towards the sun. MPPT control system is a completely electronic system which can deliver maximum allowable power by varying the operating point of the modules electrically. To obtain this maximum power from the solar panel, fuzzy logic algorithm is used in the MPPT technique. Fuzzy logic has rapidly become one of the most successful of today's technology for developing sophisticated control system. With it aid complex requirement so may be implemented in amazingly simple, easily minted and in expensive controllers. The past few years have witnessed rapid growth in number and variety of application of fuzzy logic. The application range from consumer products suchc ameras, camcorder, washing machines and microwave ovens to industrial processcontrol, medicalinstrumentation, anddecision- supportsystem. Manydecision making and problem solving task sare tooc omplex to be understoodquantitatively however, people succeed by using knowledge that is imprecise rather thanprecise. Christo Ananth et al.[6] discussed about E-plane and H-plane patterns which forms the basis of Microwave Engineering principles.

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To convert the DC voltage obtained from the SEPIC converter is converted into AC voltage using single phase three level voltage source inverter. It is connected in between the SEPIC converter and the grid. To improve the power quality of the grid PI controller is used in this paper. The DC Side Capacitor voltage is sensed and compared with a reference voltage. This error e= Vdc, ref – Vdc is used as the input for PI Controller. The error signal is passed through Butterworth design based Low Pass Filter (LPF). Then sinusoidal PWM generator is used with the PI controller to generate the gate pulses which are given to the inverter for the conversion of DC-AC. Then this AC voltage is given to the grid and the quality of the power can be improved by the SEPIC converter and the PI controller used in this paper.

II. SYSTEM DESCRIPTION

In grid connected mode of distributed generation applications, the elimination of line frequency transformer is possible without impacting system characteristics related to grid integration, ground leakage current, dc injection, safety issues etc. This paper presents the design, modeling, simulation and implementation of SEPIC Converter based closed loop operation of a novel inverter topology suitable for transformer-less single phase grid connected hybrid systems. The fuzzy logic control scheme ensures extraction of maximum power from the solar Photovoltaic (PV) and wind source, synchronization with the grid and controlled active and reactive power transfer to the grid using PI controller. Simulation results with both wind source and solar PV as input, incorporating MPPT, are discussed in this paper. The block diagram of the grid connected hybrid system with SEPIC converter is shown in figure 1.

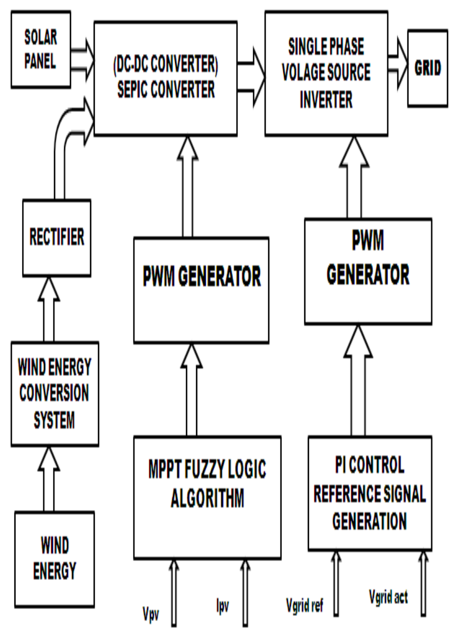

Figure 1 Block Diagram

Here, the loop is operated between the maximum size of the wind machine type chosen and the calculated minimum size of the wind machine. For each size of the wind machine, the size of solar panel is determined for the difference in load (E_L-E_w) on a daily average basis, from which the

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maximum and minimum size of the PV panel required are found. Then an inner loop for each size of the wind machine is operated between the minimum and maximum size of the chosen solar type. Next, the size of the battery system is calculated for the deficit in energy generated by both the wind and PV system on a daily basis throughout the year. Thus for each size of the wind and solar PV system combination, the maximum and minimum size of the battery are calculated. Innermost loop for every assigned size of the wind and PV system is then operated between the minimum and maximum size of the chosen battery model.

Then wind energy conversion system used here. In which the Permanent Magnet Synchronous Generator is used for the generation of three phase AC voltage. It is connected with the uncontrolled diode bridge rectifier for the conversion of AC voltage into DC voltage. Both of this DC voltage is given to the SEPIC converter to converter that variable DC voltage into fixed Dc voltage. Here, the MPPT technique is used to obtain maximum power from the solar panel. In which fuzzy logic algorithm is used. Then PWM generator block is used to generate the gate pulses. Then the fixed DC voltage is given to single phase voltage source inverter to convert it into AC voltage. The PI controller is used here and PWM generator block also used to produce gate pulses to inverter.

III. OPERATION

Hybrid power system can be used to reduce energy storage requirements. The circuit diagram of the hybrid system is shown in figure 2.

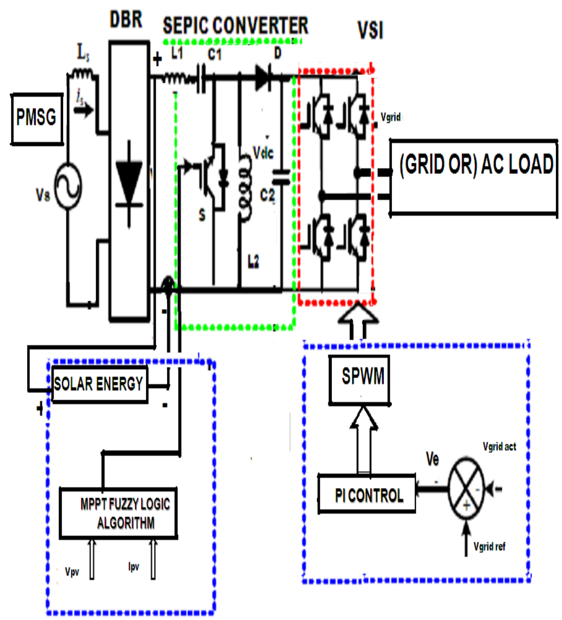

Figure 2 Circuit Diagram

The circuit diagram of the hybrid system explains the operation of the grid connected hybrid system. Temperature and intensity of the sun light is taken as the input to the solar panel. Depend upon that temperature and intensity the solar panel produces varying DC output voltage. Then the wind mills produce AC supply. Here, AC supply is produced through Permanent Magnet Synchronous Generator in Wind Energy Conversion System. This AC voltage can be converted into DC voltage using rectifier. In this paper, uncontrolled Diode

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International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE) Vol. 3, Special Issue 1, February 2017

Bridge Rectifier is used for the conversion of AC-DC. Otherwise, if choose controlled rectifier, it requires gate pulse to fire the thyristors which lead to high cost. Now, the DC output obtained from the solar panel and rectifier are given as input to the SEPIC converter. This SEPIC converter act as a multi input converter. By using it, we can obtain AC either from solar panel or from wind energy separately or simultaneously to supply to the grid.

The boosting ratio of the SEPIC converter is 1:8 and its input current is continuous. The output voltage of SEPIC converter is constant. It converts the variable DC voltage into fixed DC voltage and also boosts the output voltage. The ripple content in both current and voltage can be reduced byit. In which MPPT technique is used to extract the maximum power from the solar panel. In which fuzzy logic algorithm is used to compare the actual voltage with the reference voltage and produce the error value. Based on this error value the reference signal is adjusted in PWM generator which is compared with the carrier signal to produce the gate pulses. This gate pulses are given to the switch in the SEPIC converter to extract maximum power from the solar panel without any losses. The output of SEPIC converter is given to the single phase three level voltage source inverter. It is used to convert the DC voltage into AC voltage and given to the grid. The PI controller is used with the PWM generator to produce pulses given to the inverter.

IV. MODELLING OF SEPIC CONVERTER

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. There are two modes of operation during turnon and turnoff of the MOSFET. These can be explained as below. In mode1 operation the gate pulse is given to the MOSFET so that, it can be turned on for further operation.

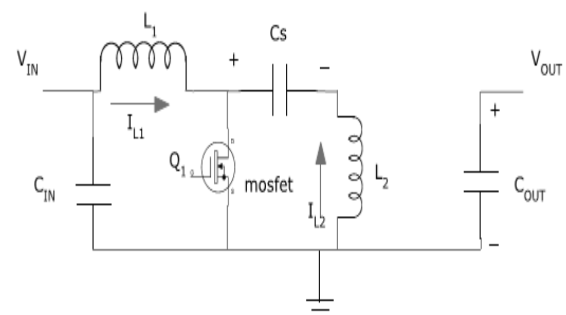

Figure 3 Mode1 Operation of SEPIC converter

Mode1 operation of the SEPIC converter is explained using figure 3. During this operation, the diode having reverse bias so that, it does not conduct for that period. Now the voltage across the inductor L1 is given by,

$$V_{IN} = V_{L1(ON)} \quad (1)$$

$$V_L = L\frac{di}{dt} \quad (2)$$

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International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE) Vol. 3, Special Issue 1, February 2017

$$\frac{\Delta I_{L1}}{T_{on}} = \frac{V_{L1(ON)}}{L_1} \quad (3)$$

In mode2 MOSFET in off condition. The circuit diagram for mode2 operation of SEPIC converter is shown in figure 4. During the MOSFET is in off condition, current does not flow through the MOSFET. At that time the diode is in forward condition so that, the current flow through it.

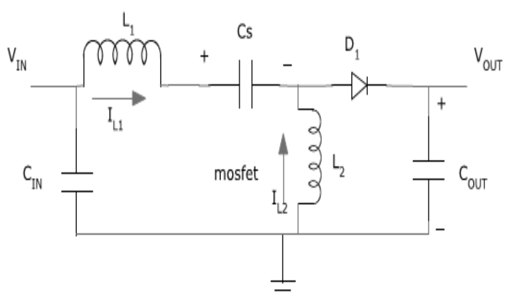

Figure 4 Mode2 Operation of SEPIC converter

Now the voltage across the inductor is given by,

$$V_{L1(OFF)} = Vc_s + V_{OUT} - V_{IN} \quad (4)$$

$$L\frac{di}{dt} = Vc_s + V_{OUT} - V_{IN} \quad (5)$$

$$\frac{\Delta I_{L1(off)}}{T_{off}} = \frac{Vc_s + V_{OUT} - V_{IN}}{L_1} \quad (6)$$

The output of an ideal SEPIC converter is

$$V_0 = \frac{D * V_i}{1-D} \quad (7)$$

Equation (7) shows the output voltage of SEPIC converter. From this equation, duty cycle can be calculated easily.

V. SIMULATION RESULTS

The grid connected hybrid system is implemented using MATLAB/Simulink. The result was obtained and analyzed in this section.Figure 5 shows the simulink blocks of the solar panel, PMSG, fuzzy system, PI controller, SEPIC converter and the grid tied inverter also.

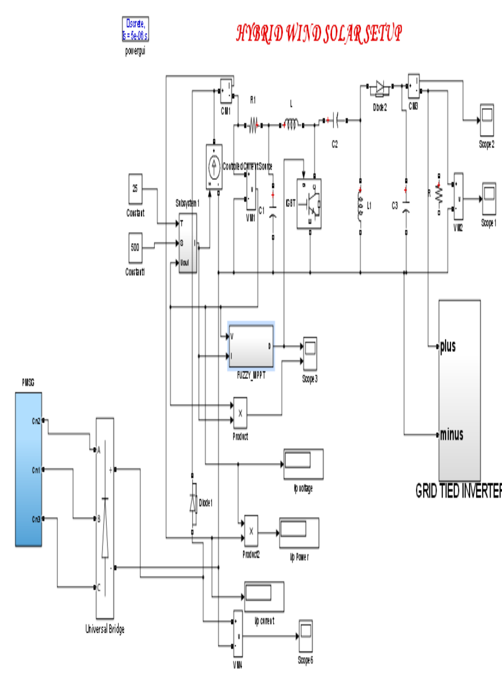

Figure 5 Matlab Simulink

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International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE) Vol. 3, Special Issue 1, February 2017

Using this Matlab Simulink, the result which is produced by the inverter to the grid using control techniques can be obtained easily. Then the result obtained from each block are detail explained below.

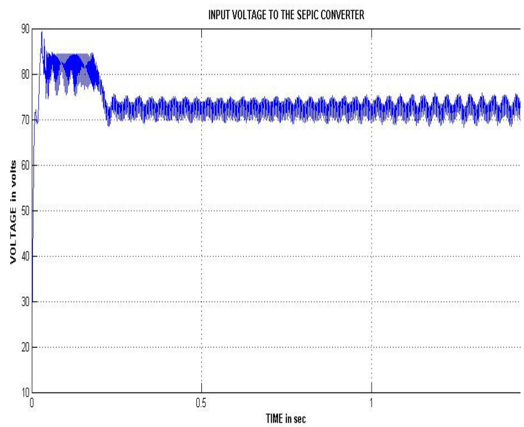

Figure 6 Input DC Voltage to the SEPIC converter

Figure 6 shows the input DC voltage which is given to the SEPIC converter. This input DC voltage is obtained from the solar panel and the output of the rectifier. This DC voltage contains some amount of ripple contents.

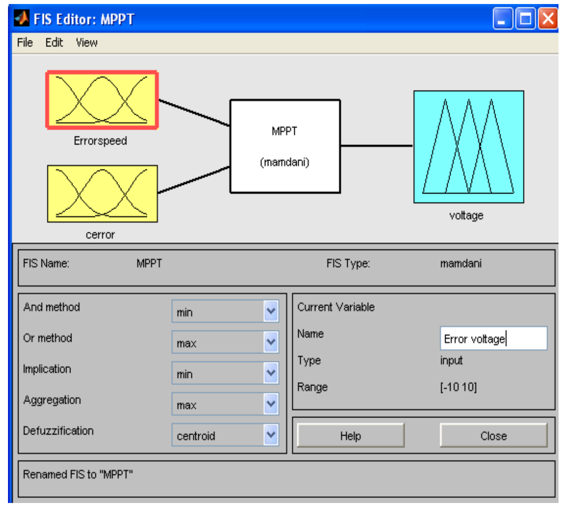

Figure 7 Fuzzy Logic Triangular Membership Function

Figure 7 shows the fuzzy logic triangular membership function which is used in the Maximum Power Point Tracking technique to obtain maximum power from the solar panel. The rules are created to generate the reference pulses in this section.

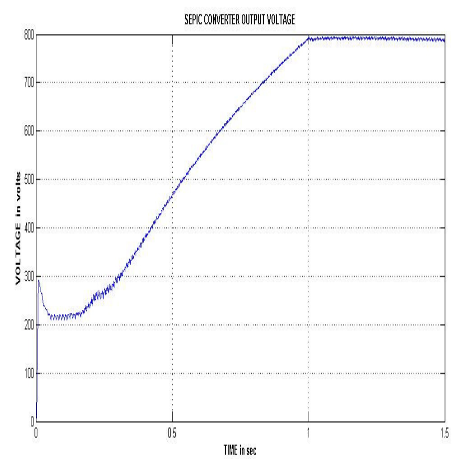

Figure 8 SEPIC Converter Output Voltage

Figure 8 shows the output DC voltage of the SEPIC converter. The reduced ripple content is given ac DC output voltage of SEPIC converter. This fixed DC

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International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE) Vol. 3, Special Issue 1, February 2017

output voltage is given to the single phase three level voltage source inverter.Figure 9 shows the output voltage of the voltage source inverter which is obtained through the filter to reduce the harmonic contents. So that the voltage sag, voltage swell problems are not occur.

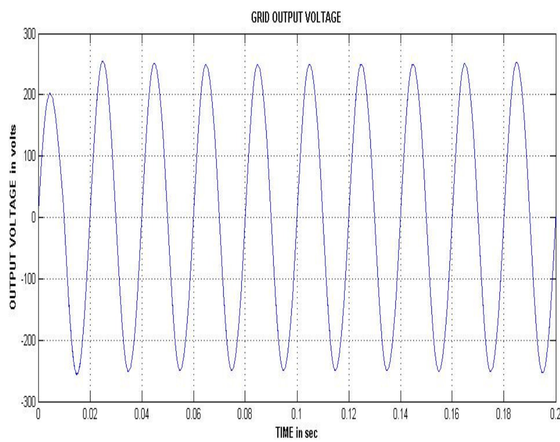

Figure 9 Inverter Output Voltage with Filter

When the harmonic get reduced, the Total Harmonic Distortion get reduced automatically.

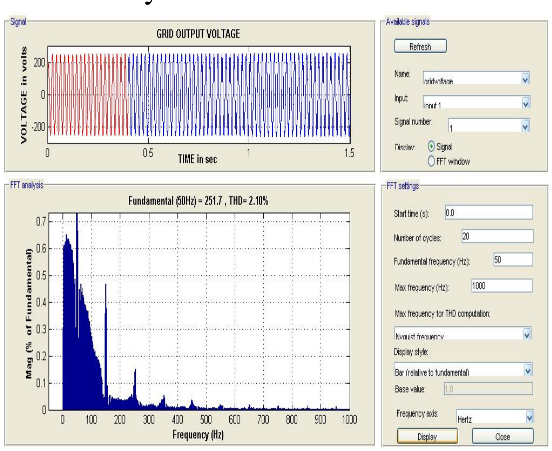

Figure 10 Inverter Voltage THD Waveform Using FFT Analysis

Figure 10 shows the THD waveform of inverter voltage using FFT analysis. It shows the reduced THD level of 2.10% at the display for 20 number of cycles.

VI. CONCLUSION

A new reliable hybrid DG system based on PV and wind driven PMSG as sources, with only a boost converter followed by an inverter stage, has been successfully implemented. The mathematical model developed for the proposed DG scheme has been used to study the system performance in MATLAB. In addition, it has been established through simulation that the two controllers, digital MPPT fuzzy logic controller and PI controller which are designed specifically for the proposed system have exactly tracked the maximum powers from both the sources. Maintenance free operation, reliability and low cost are the features required for the DG employed in secondary distribution system. . The steady state waveform captured at grid-side show that power generated by the DG system is fed to the grid at unity power factor. The voltage THD and the current THD of the generator meet the required power quality norms recommended by IEEE. The proposed scheme easily finds application for erection at domestic consumer sites in a smart grid scenario.

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ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
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International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE) Vol. 3, Special Issue 1, February 2017

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