Modified Fuzzy Controller of 3 Port DC-DC Converter Application for Renewable Energy Sources

P.Sundaramoorthi[1] Gigi George[2]
[1]Assistant Professor [2]PG Student
[1,2]Department of Electrical & Electronics Engineering
[1,2]Nehru College of Engineering and Research Centre, Thrissur, Kerala

Abstract— Renewable energy sources have been one of the best alternative to ensure reliable energy source as it omnipresent free of cost and causes minimum environmental concerns. Among available renewable sources, photovoltaic (PV) generation, integrated with power backup storage unit, has been optimal choice for loads. The project proposes a fuzzy based three-port converter for simultaneous power management of multiple energy sources. The proposed converter has the advantage of using the least number of switches. The converter is capable of interfacing sources of different voltage current characteristics with a load. The proposed converter is constructed for a photovoltaic panel, Wind generator, a rechargeable battery, and a load. The efficiency of the converter is verified through MATLAB simulation. The proposed converter has reliability operate simultaneous power generation from different renewable energy source. Fuzzy controller controls the direction of power flow and load voltage of the converter.

Key words: Multiport Converter, Buck Boost Converter, Fuzzy Logic, MPPT, PV, Wind Generator

I. Introduction

Today's world has the interest to developing hybrid energy generation system, from different kind of renewable energy source. The hybrid energy generation system consist of some main issues are stability, reliability, and power quality. To use these problems storage element is used. The clean power generation world prefer PV panel and wind generation system. Multiport DC-DC converters have been proposed to do the efficient power management and load integration for the multiple sources.

To integrate multiple DC energy sources of different types to a power grid, multiple independent DC–DC converters are commonly used to step up the time-variant low-level source voltages to a constant high-level voltage that is required by a grid-tie inverter. Comparing to that solution, a multiport DC–DC converter is preferable, owing to the advantages of using fewer components, lower cost, higher power density, and higher efficiency.

The multiport dc-dc converter with energy storage has become a promising option for many instead of power systems, which including fuel cell vehicle, hybrid vehicle, renewable energy application and so on. It not only reduces the cost and improves the efficiency of the system performance. With its ability to reverse the direction of current flow and power. The multiport dc-dc converters are used to achieve the power transfer between sources and load. It is also regulated by the solar panel photovoltaic(PV) level and wind turbine generator (WTG) wind level, thus to maintain a stable load voltage and make fully usage of the solar panel and wind turbine generator and the storage element battery.

The proposed converter has the least number of switches and thereby a lower cost. The newly introduced converter is applied for power management of a wind/solar hybrid generation systems, which consists of a WTG and a PV panel. The power generation from solar and wind energy are designed using perturbation and observation (P&O) MPPT algorithm, in which the WTG and PV panels can be controlled at the same time and extract the maximum power.

II. Proposed Three Port Converter

The complete hardware setup of the proposed converter is shown with lamp load Fig.1. In this scaled down setup, the hybrid system are connected as input to the inverter, which is then connected to the synchronizing panel circuit to feed the domestic load. The switching pulses of the main inverter circuit are given from PWM pulse circuit generated through programming in dsPIC microcontroller. Hybrid sources are directly connected to bi- directional boost converter, then to the transformer less inverter and the supply is given to the load through synchronizing panel. The switching pulse for transformer less inverter is generated from dsPIC4011, a high performance Digital Signal Controller.

A DC input voltage of 20 V is engaged from solar PV cell and 1 watts of wind system, is transferred to bi-directional converter. The bi-directional boost converter as the input ranges from 0 to 12 V which feeds the boosted output voltage of 24 V to the transformer less inverter. The transformer less inverter converts input DC in to output voltage of AC ranging from 150 to 200. Synchronizing panel with double-end contractor compares sources, one from the inverter and other from the grid supplied to domestic loads such as lamp etc.

Fig. 1: Hardware setup of Proposed Converter

Simulation results are validated through the experimental setup and the block diagram of the overall setup is shown in Figure1. A high performance digital signal controller dsPIC controller is used to generator PWM signal for transformer less inverter by respective programming. The dsPIC4011 is a High Performance Digital Signal Controllers with CPU module has a 16-bit (data) modified Harvard architecture with an enhanced Instruction set, including significant support for DSP. The instruction set includes many addressing modes and was designed for optimum C compiler efficiency.

A. *dsPIC Features:*

1) High performance modified RISC CPU
2) 48 Kbytes on-chip Flash program space (16K Instruction words)
3) 2 Kb of on-chip data RAM and 1 Kb of non-volatile data EEPROM
4) 4. 4 MHz- 10 MHz oscillator input with PLL active (4x, 8x, 16 as)
5) 5. 16 x 16- bit working register array
6) 6. Timer module with programmable presale
7) 7. 6-bit Capture input and 16- bit Compare/PWM output functions
8) 8. 2 UART modules with FIFO Buffer
9) 9. 6 PWM output channels
10) 10. Analog-to-Digital Converter (A/D) with 4 S/H Inputs

According to the in-built program in dSPIC4011 controller, the duty-cycle is varied which varies the output voltage of transformer less inverter. The duty ratio is $D = 1 - \frac{V_{in}}{V_o}$. With the value of the duty cycle, D will always ranges between 0 and 1 and hence it is important to maintain the output voltage higher than the input voltage in magnitude.

III. MATLAB/SIMULINK MODEL OF PROPOSED THREE PORT CONVERTER

The proposed three port converter uses three sources such as PV source, wind generator and a battery. The simulation model of proposed system is shown in fig.2

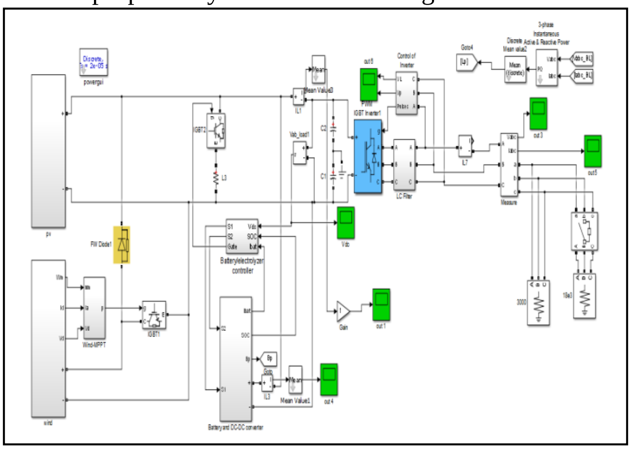

Fig. 2: Simulation Model of Proposed System

A. *PV Source*

Here both PV power and PV voltage is generated by using P & O MPPT technique. Second one is wind source. Fig.3 shows the simulation model of PV source

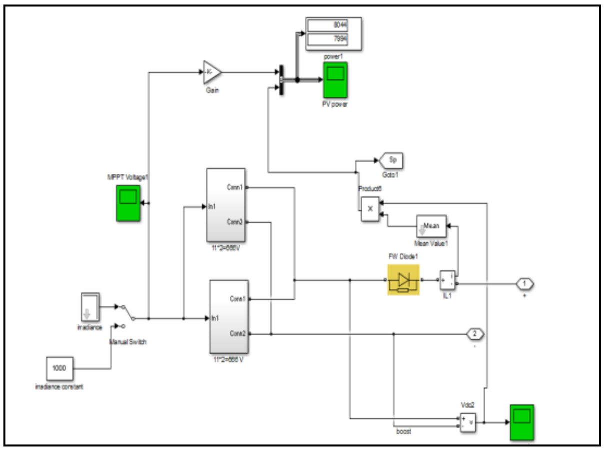

Fig. 3: Simulation Model of PV Source

B. *Wind Source*

Wind source is the generator model. Usually wind is generated in the form of AC. Here a three phase AC is generated and it is converted in to DC by using a rectifier circuit. Fig.4 shows the simulation model of wind source.

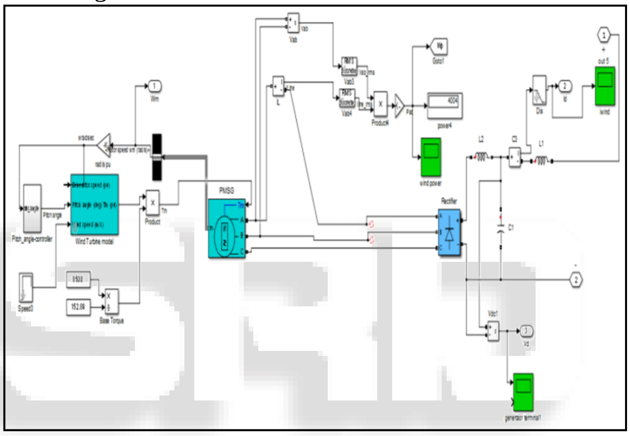

Fig. 4: Simulation Model of Wind Source

C. *Battery and DC to DC Converter*

The proposed system uses 200V battery system. It is along with a DC to DC boost converter. Its simulation model is shown in fig.5. Battery will generate some ripples. The DC to DC converter reduce the ripples present in the system and give efficient output of battery system. When battery is charging SOC(State of Charge) will be high otherwise SOC will be decresed. Here SOC is maintained. If 80% of SOC is attained then it will cut off.

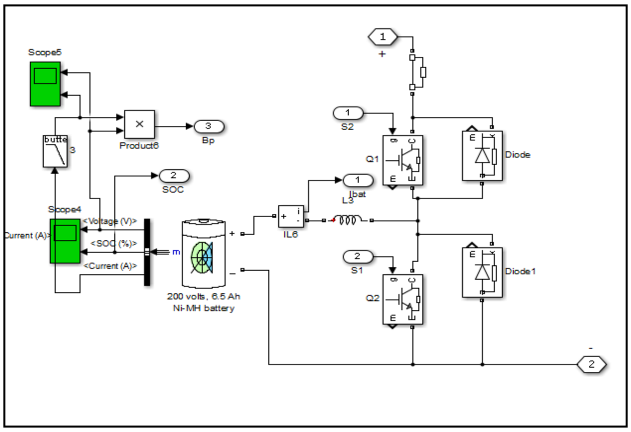

Fig. 5 Simulation Model of Battery with DC- DC Boost Converter

D. Battery Controller

It will generate PWM signals for DC to DC converter and this is with fuzzy model control. PWM signals are generated through fuzzy control system and are fed to the DC to DC converter. Battery controller consists of two switches S1 and S2. These switches need PWM signals for their operation. And a PI controller controls the output values through fuzzy system.

1) Battery controller creates two logics;

1) If solar is not available, wind is available
   It will take the power from wind and also it will store the excessive power to the battery through DC to DC converter.
2) If PV is available but wind is not available
   Then it will deliver the power to the load and also stored excessive power to the battery
3) If both the sources are not available
   It will take all the power from the battery and fed to the inverter. Fig.6 shows the simulation model of battery controller.

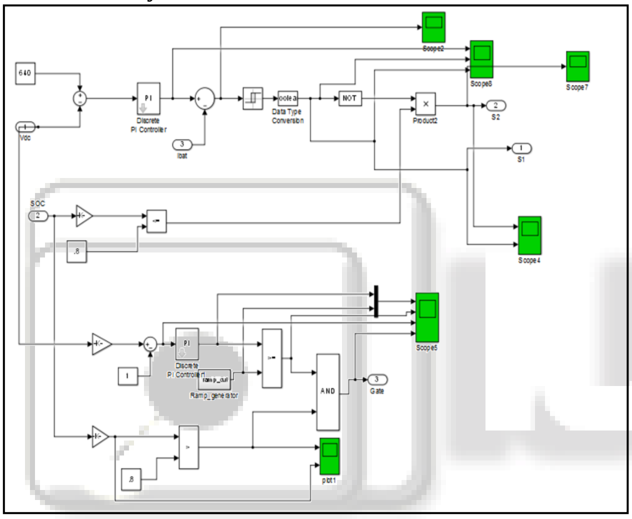

Fig. 6: Battery Controller

E. Surface View of FUZZY System

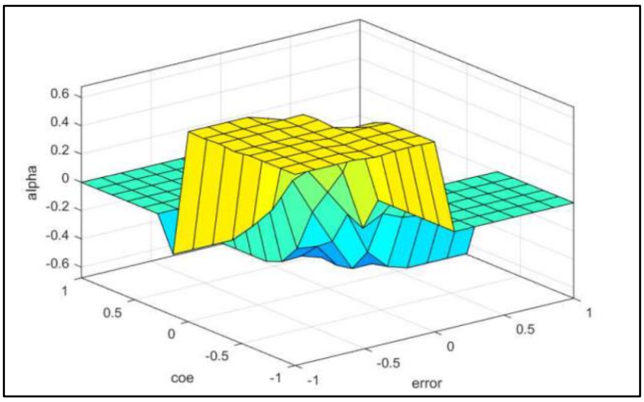

Fig. 7: Surface view of FUZZY System

In this figure yellow colour indicates the stability of the system. It represents all the parameters are stable. Here using 49 rules based fuzzy system. If rules are high system will have more stable. In the proposed system can achieve 80% of stability compared to the conventional system.

IV. RESULTS AND ANALYSIS

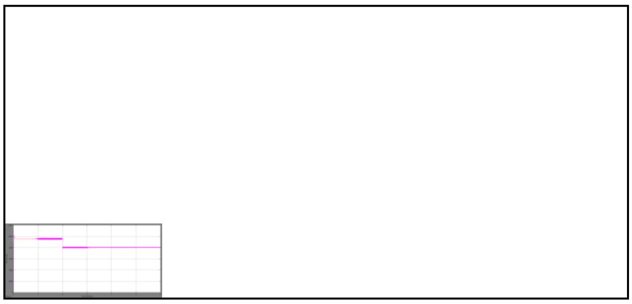

Fig. 8: Output Waveform of Solar Power

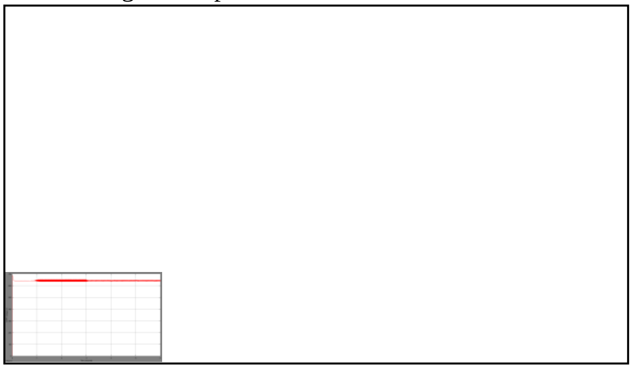

Fig. 9: PV Output Voltage

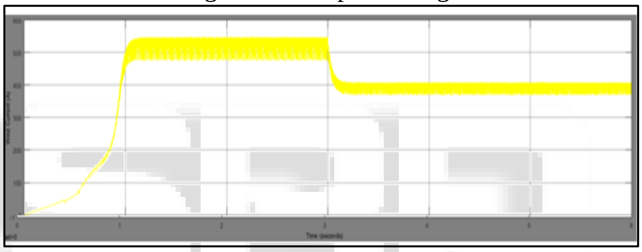

Fig. 10: Output Waveform of Wind Voltage

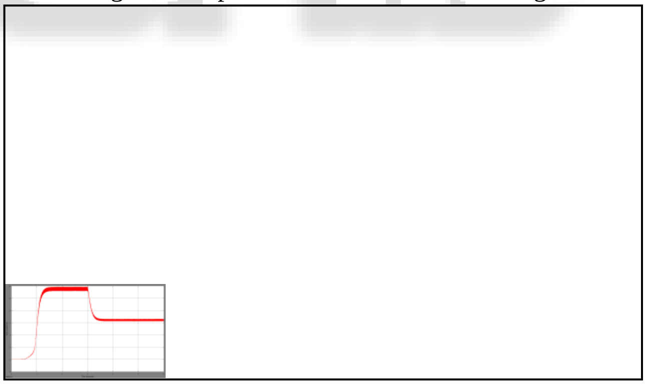

Fig. 11: Output Waveform of Wind Current

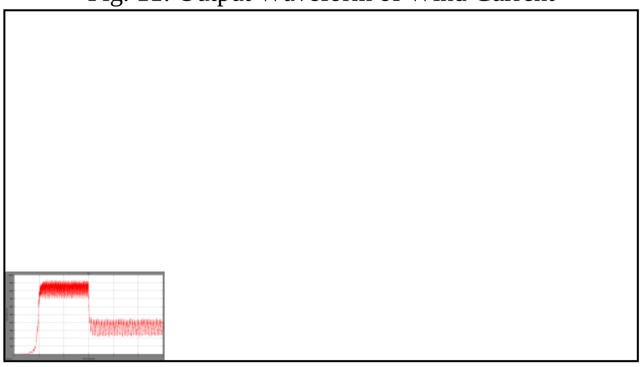

Fig. 12: Output Waveform of Wind Power

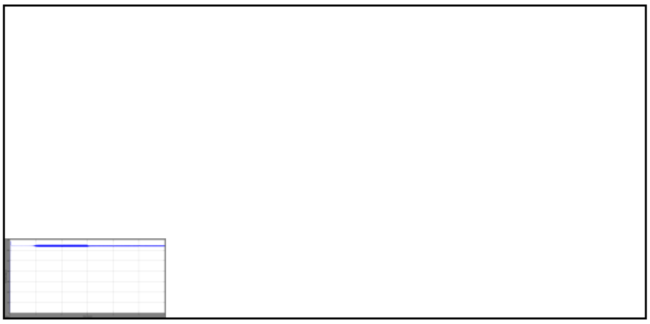

Fig. 13: Output DC Voltage

V. CONCLUSION

The topology of fuzzy with modified transformer less three port converters has been study. Simulation with fuzzy has been done and output voltage ripple has reduced, with the fuzzy complexity has reduced and it can be used in PV plant, solar pumping etc. Three port dc–dc converters that use the minimum number of switches have been proposed for simultaneous power management of multiple renewable energy sources. The proposed converter has been applied for simultaneous power management of a three-source wind/solar hybrid generation system. The experimental results show the effectiveness of the proposed converter. The advantage of the proposed multiport dc–dc converter is its simple topology while having the capability of MPPT control for different renewable energy sources simultaneously. Moreover, the proposed converter can be easily applied for power management of other types of renewable energy sources. In future the hybrid energy system can be further altered to some other renewable sources like PV-Fuel cell Hybrid Energy System to meet large load depending on various applications.

REFERENCES

[1] Christy Mary Jacob and Jisha James, “Three Port Converter Topology for grid interfacing of Renewable Energy Sources “, International Journal of Advanced Information Science and Technology, vol.30, no.30, pp.150 - 155, October 2014.
[2] Zhijun Qian and Hussam Al-Atrash,” Modeling and Control of Three-Port DC/DC Converter Interface for Satellite Applications”, IEEE Transactions On Power Electronics, vol. 25, no. 3, pp. 637-649, March 2010.
[3] N. Zhang, D. Sutanto & K. M. Muttaqi, "A review of topologies of three-port DC- DC converters for the integration of renewable energy and energy storage system," Renewable and Sustainable Energy Reviews, vol. 56, pp. 388-401, 2016.
[4] Santhi Mary Antony A,” Closed Loop Control of Three Port Converter with High Voltage Gain”, International Journal of Engineering and Technology, vol. 7, no. 4 pp. 1224-1235,Aug-Sep 2015.
[5] R. B. Devi and S. M. Balaganesan, “Design and Implementation of Multiport Bidirectional DC-DC Converter for Hybrid Energy Storage Systems”, ARPN Journal of Engineering and Applied Sciences, vol. 10, no. 7,pp. 2873-2875, April 2015.