International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-7, Issue-6S4, April 2019

Optimizing the Power Generation of Co-Located Wind Solar System with Fuzzy Controls

K. Barathi, P.K.Dhal

***Abstract*—The Fuzzy Logic Controllers are proposed for the Co-Located Wind Solar Hybrid system for optimizing the power and also support load during the low wind day. The 900V,100Ah battery bank supports during low wind day. The Fuzzy controllers and Battery bank with Co-Located Wind-Solar system is modeled in MATLAB/ Simulink software to derive increase in total output power efficiency of 33.3%.The increase in total power efficiency consists of 13.6% from Solar,11.2% from wind and Battery bank 8.5%.The battery get charged during high wind and high sunny time and supplies during low wind day and night time.**

***Key words*—Co-Located Hybrid System, Fuzzy based boost converter,Solar System, Wind System, Fuzzy Logic Controller, MATLAB/Simulink**

I. INTRODUCTION

India's fast growing industrialization and automation in every sector causing more pollution and spoiling the environment. India is having major challenge of green house gases which effecting the environment and also health of the citizens. The only solution to reduce the green house gases is the looking for renewable energy sources to meet both Industrial and Domestic power needs. The tapping of Renewable energy sources is economically viable option and also reduce the dependency of fossil fuel. India is already generating the electricity from the wind source. An attempt has been made by the Indian government to add Solar system to the existing wind system which is in Tamilnadu and becomes India's first "Co-located Hybrid system". The advantages of the Co-located Hybrid system is that the existing resources of wind system could be shared by the Solar system like land, part of Converter and Inverters.

In this project work it is proposed that in Solar side, a Fuzzy control is added between Solar array output and Boost converter to derive the maximum power. As per the Betz's law the efficiency of the wind turbine can never be better than 59.3% theoretically. A fuzzy control is implemented at Boost converter which controls the On/Off operation of the switch to track the maximum power. The battery bank get charged by the either of the source i.e Wind or Solar. The outputs of the Solar, Wind The Co-Located Wind-Solar System with Fuzzy Logic controllers and Battery Bank are simulated to show improved power efficiency and viability to upgrade all future co-located hybrid systems.

Revised Manuscript Received on April 05, 2019.

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II. OBJECTIVES

In this paper, the below mentioned two objectives are achieved through simulation:

i) To optimize the power generation of Co-located wind Solar systems with Fuzzy controls.

ii) To Support the Grid/Load during low wind by Battery bank.

III. THE CO-LOCATED HYBRID SYSTEM

The Co-located Hybrid system is formed by adding Solar system to the existing Wind system. In this paper Fuzzy controllers are added to both solar and wind systems. In addition, a battery bank is added to the system to support the load during low wind day and no sunny periods. The block diagram of the co-located system is shown as figure 1.

PV Array

Fig.1.Block Diagram of the Co-Located Hybrid System

The PV Array consists of 30 modules arranged in series and parallel combination. Each module consists of 05 cells connected in series. The PV array with Boost converter and FLC circuits produces an output of 920VDC.The Wind turbine converts wind speed and blade pitch angle into kinetic energy which in turn drive the permanent magnet synchronous generator. The PMSM produces the AC output that in turn is converted to DC by the converter circuit. The FLC is implemented between Converter and Boost converter.

The Output from the Boost converters from both systems are connected to the Inverter and Battery bank. The Inverter converts the DC power into 3 Phase AC power to supply to the Grid / AC loads.

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IV. FUZZY LOGIC CONTROLLER MODEL

The mamdani Fuzzy Logic controller is designed with centroid for defuzzification process and simulated FLC blocks as shown in Fig 5.

There are two inputs to the Fuzzy Logic controller; one input variable is power (dp) that has eight abbreviated membership functions like NB (Negative Big),PM(Positive Medium),PS(Positive Small), ZE(Zero), NS(Negative Small), NM (Negative Medium), PB(Positive Big), NM (Negative Medium) as shown in fig 2.

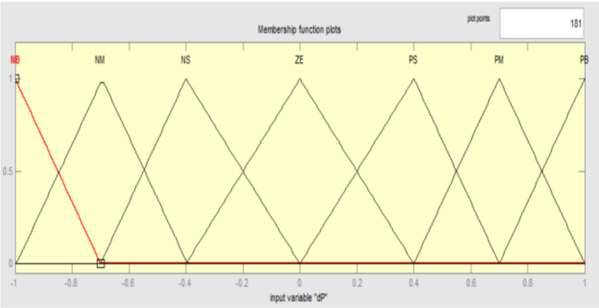

Fig. 2. Input Power variable

The other input variable is voltage (dv) that has three abbreviated membership functions like N(Negative),P(Positive) and Z(Zero) as shown in fig 3.

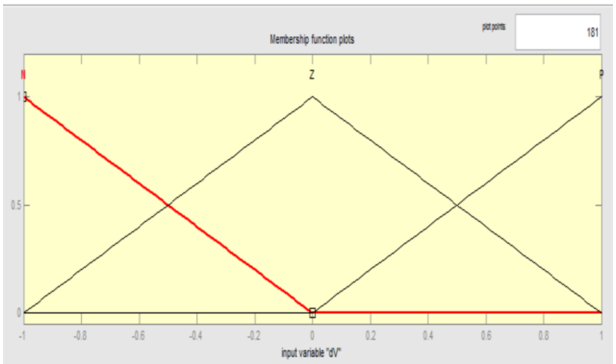

Fig. 3. Input Voltage variable

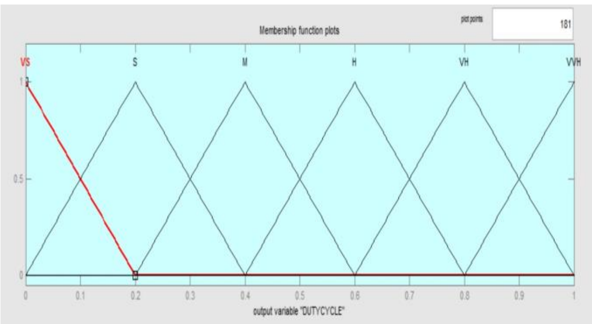

Fig. 4. Output variable – Duty Cycle

The output variable is Duty cycle and has six abbreviated membership functions like VS (Very Small), S(small), M(Medium), H(High), VH(Very High), VVH(Very Very High) as shown as figure 4.

The fuzzy truth table is framed by using above said linguistic variables with if-then logic as shown in TABLE I.

TABLE I FUZZY TRUTH TABLE

dp\dv	N	P	Z
NB	VS	VS	H
PM	VH	VH	H
PS	VH	VH	H
ZE	H	H	H
NS	M	S	H
NM	S	-	H
PB	VVH	-	H
NM	S	-	-

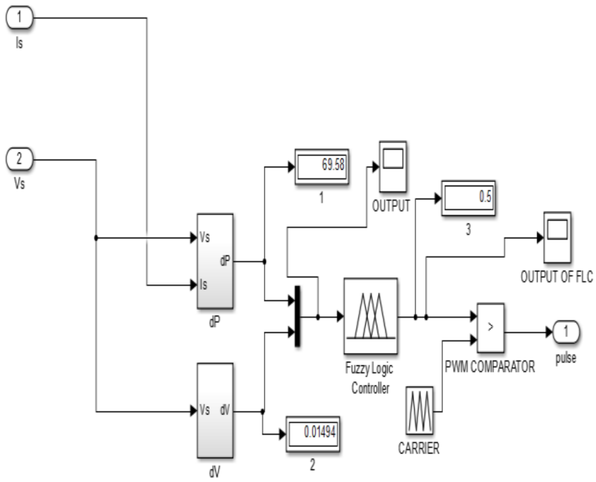

Fig.5. Simulated fuzzy logic controller

V. MATLAB SIMULATION OF PROPOSED SYTEM

The Co-Located Hybrid system with fuzzy controllers, Boost converters,3Φ Inverters is simulated on MATLAB/Simulink 2014 version and it is shown in figure 6.

The simulation results of the Existing and Proposed systems are as follows:-

A) The existing Co-located Wind-Solar system also simulated without fuzzy controllers and battery bank and found the output as follows:-

i) The stand alone Solar system produced output =810VDC as shown in figure 7.

ii) The stand alone Wind system produced output @Pitch angle:20Deg,Wind Speed:50m/s =520VDC.

iii) The stand alone Wind system produced output @Pitch angle:20Deg,Wind Speed:65m/s =720VDC as shown in figure 9.

iv)The net output of the integrated wind-solar system = 519W

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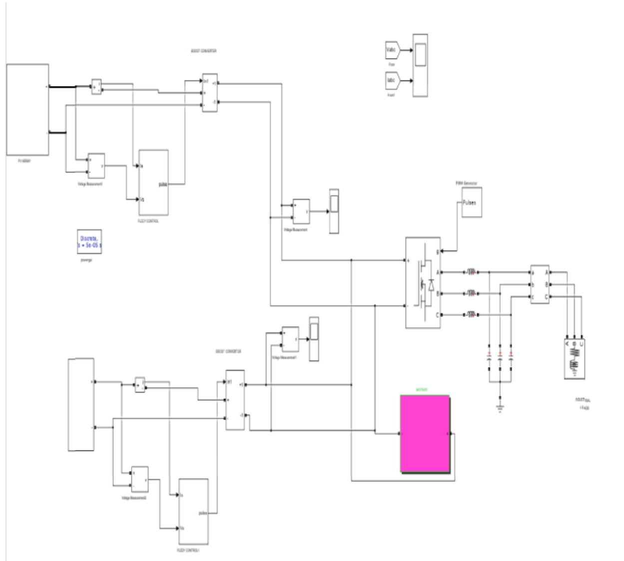

Fig. 6. The complete simulation of the Co-Located Wind-Solar system

B) The Proposed system various subassemblies composition and their performance as follows:-

Solar array consists of 30 modules and arranged in series and parallel combination. The series arm consists of 03 modules and parallel arm consists of 10 modules. Each module consists of 05 cells connected in series and produces output voltage of 104VDC.The complete Solar array produces the output of 312VDC.The Boost converter steps up the voltage to 810VDC.A Fuzzy controller produces the output signal based the input membership functions and rules .The inclusion of fuzzy controller raises the output to 920V in Solar side when operated in standalone as shown in figure 8. The Wind Energy conversion system along with fuzzy based boost converter (Wind turbine, gear box and Permanent Magnet synchronous Generator) converts the wind speed from 50 m/s to 65m/s and pitch angle of 20Deg with PMSM speed of 1pu into 580VDC and 800V (as shown in figure 10)respectively. A 900V,100Ah Lead Acid Battery bank is added to the Wind Solar system to charge during high wind days and steadily deliver to the load during normal and low wind days. The pooled battery output is inverted to 3Phase output voltage by an 3Phase Inverter. The afore said elements are simulated in interconnected fashion as Co-Located Fuzzy controlled Wind Solar System and derived output of 692W.

The simulation results evaluation of the existing and proposed systems is tabulated as Table II:

TABLE II SIMULATION RESULTS EVALUATION

Parameter	Existing System	Propose d system	Percentage Improvement in output
Stand alone Solar system output Voltage	810VDC	920VDC	13.6%
stand alone Wind system produced output @Pitch angle:20Deg, Wind Speed:50m/s	520VDC	580VDC	11.5%
stand alone Wind system produced output @Pitch angle:20Deg, Wind Speed:65m/s	720VDC	800VDC	11.1%
Additional power added by the Battery Bank	-	-	8.2%
Net output of the Co-Located wind-solar system	519W	692W	33.3%

VI. VI.SIMULATION RESULTS

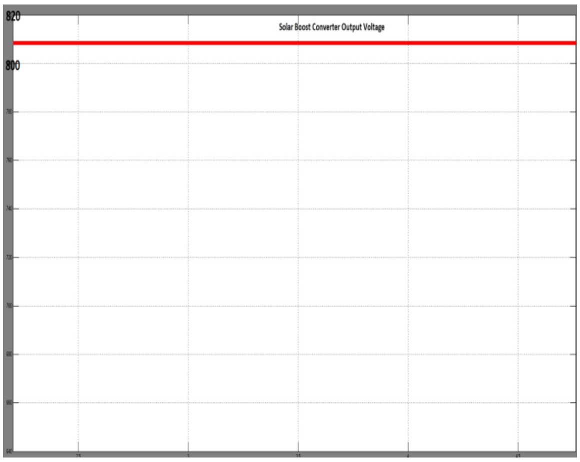

Fig.7.The Stand alone Existing Solar Booster output voltage.

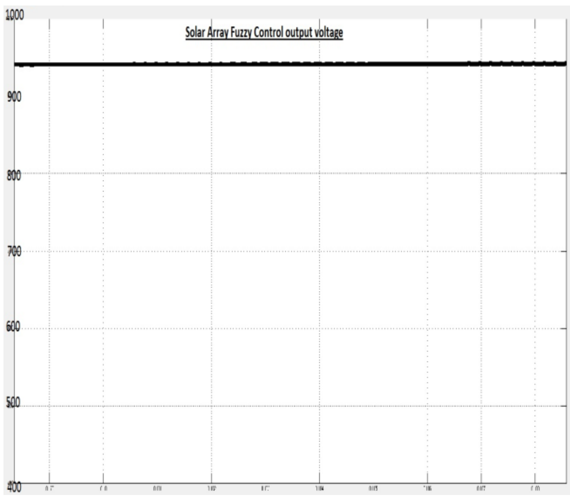

Fig.8. The Stand alone Proposed Fuzzy Controlled Solar Booster output voltage.

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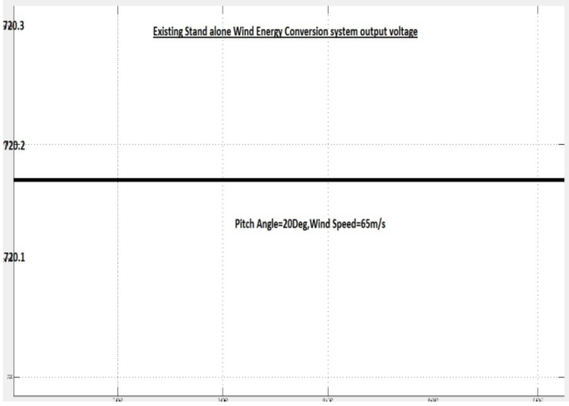

Fig.9. The Stand alone Existing Wind system output voltage.

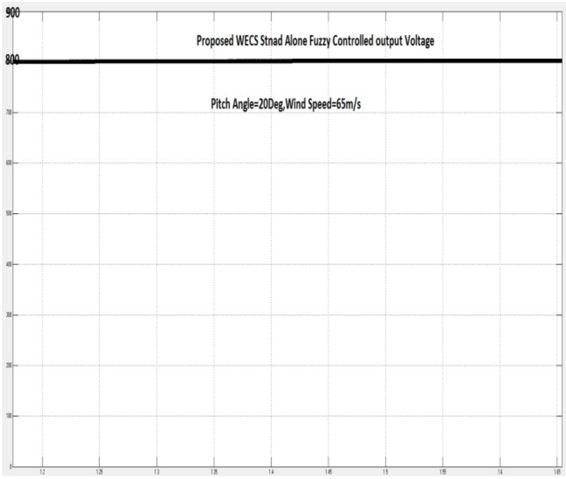

Fig.10. The Stand alone Proposed Fuzzy Controlled Wind system output voltage.

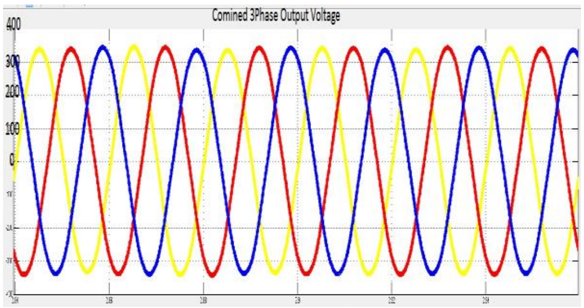

Fig.11. The total output voltage of the Existing System

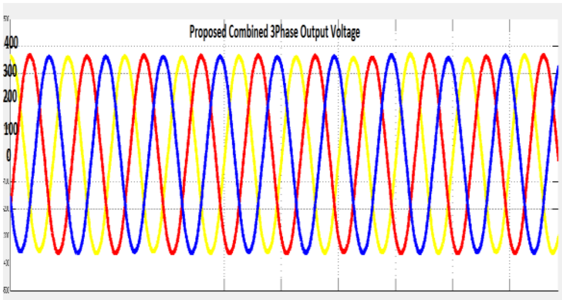

Fig.12. The total output voltage of the Proposed System

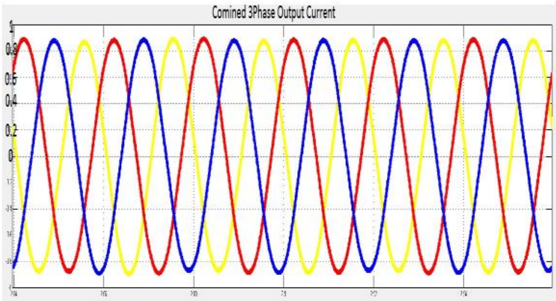

Fig.13. The total output current of the Existing System

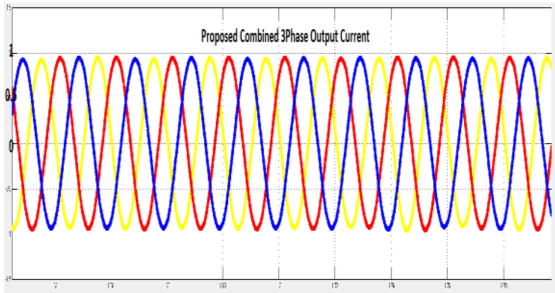

Fig.14. The total output current of the Proposed System

VII. CONCLUSIONS

This paper proposes the optimizing the power generation of the Co-Located Wind-Solar system with Fuzzy controllers. The Fuzzy logic controller in the Solar system raised the output from 810VDC to 920VDC.The Fuzzy logic controller is incorporated in the Boost converter of Wind system has raised from 520V to 580VDC at Pitch angle of 20Deg,Wind Speed of 50m/s and from 720V to 800VDC at Pitch angle of 20Deg,Wind Speed of 65m/s.The addition of 900V,100Ah battery bank has also given boost in the output power efficiency of 8.2%.The stand alone fuzzy based system has shown improvement of 13.6% and wind system of 11.2% and the net output rosen from 519W to 692W .The total efficiency of the fuzzy based co-located wind-solar system has shown power growth of 33.3% during simulation.

Hence, the objectives of optimizing the power performance of the Co-located wind-solar system are achieved through fuzzy controllers. The addition of battery bank has realized power delivery during low wind day.

VIII. ACKNOWLEDGMENT

We express our deepest gratitude to our respected Founder President and Chancellor **Col.Prof.Dr.R.Rangarajan** B.E. (EEE), B.E. (MECH), M.S (AUTO). DSc., Foundress President **Dr.R. Sakunthala Rangarajan** M.B.B.S., Chairperson Managing Trustee and Vice President. We extremely thankful and pay my gratitude to our **Dean Dr.V. Jayasankar Ph.D** and Head of the Department and Project Co-ordinator **Dr. P.Chandrasekar Ph.D.,** for their valuable guidance and support on completion of this project in it presently.

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