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FNN BASED INVERTER CONTROLLER FOR SOLAR WIND HYBRID RENEWABLE POWER SYSTEM

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ABSTRACT

Use of Renewable energy sources for power production is increasing day by day. In this paper Fuzzy Neural Network is proposed to get regulated power from the renewable energy sources. A stand-alone hybrid power generation system consisting of solar and PMSG with AC load is designed in this paper. Additionally P & O algorithm for Solar and Hill climbing search algorithm for Wind are used as the control logic for the Maximum Power Point Tracking (MPPT). The proposed controller for inverter is intended to keep the load voltage and frequency as constant regardless of the renewable power generation. Comparative Simulation results with Fuzzy logic controller for inverter show the effectiveness of the proposed controller.

KEYWORDS: *Renewable Hybrid System, Fuzzy Logic, FNN, Inverter Control*

Article History

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INTRODUCTION

The industrial revolution brings a significant improvement in the human ability to extract more energy from naturally available resources such as oil, coal, and gas, because they are cheap, abundant, and easy to harvest but, this way of harvesting energy in the 21st century becomes not efficient due to the expansion of energy demand across the world and the occurrence of global warming, which claimed that extracting and using vast amounts of fossil fuel are the leading cause of it. In recent years, renewable energy resources (RES) are becoming the world focus and grabbing the attention of many governmental organizations. Researchers consider renewable energy sources the promising energy sources amidst the fear of natural resource depletion and environmental issues such as high levels of CO_2 and other harmful emissions. Some of the other reasons comprise advantages like abundant availability in nature, eco-friendly and recyclable. Solar and wind energy are the world's rapid growing energy resources compare to all renewable energy sources. Distributed Generation (DG) is a replacement for centralized power generation plants. Along with the use of DGs, by adding Battery Energy Storage (BES) the reliability of RES can be improved. The environmental conditions can change rapidly for example photovoltaic system is ideal for the places having more illumination levels and wind power system is ideal for locations having favourable wind flow conditions [3]. It is better way to use the hybrid source power system which 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]. The significant characteristic of hybrid power system includes, system reliability, operational efficiency [1].

In a PV system, a solar cell alone can produce power of 1 to 2 watt [5]. The solar cell is modelled 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. 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].

In the wind energy system, wind is used to generate electricity. Wind energy system includes wind turbines, which converts the kinetic energy in wind into mechanical power. For RES especially the variable speed wind energy conversion systems, includes (PMSG) generator, which can convert mechanical power into electricity. The output of wind power is not stable, it is variable.

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].

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. 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 using Boost converter with MPPT controller at each source. The control logic of the MPPT controlled boost converter for the Wind power generation and PV based generation are selected on the basis 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 modelling and simulation on the entire PV/wind/battery hybrid system is carried out under Matlab/Simulink environment.

HYBRID RENEWABLE SYSTEM

The block diagram of PV-wind hybrid power system is shown in Fig. 1. The hybrid generations consist of Photovoltaic based generation, Wind Power Generation, Battery; Voltage regulated inverter and AC load.

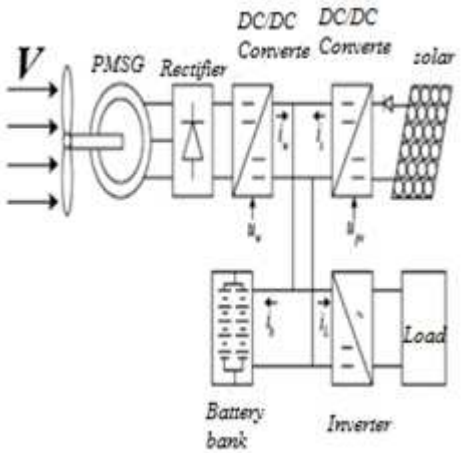

Figure 1: Block Diagram of PV-Wind Hybrid System.

Perturb and Observe MPPT Algorithm for P.V. Array

Perturb and Observe (known as P&O) algorithm, shown in Fig, is used in this project for maximum power tracking of the P.V 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 P.V. array, then the same direction of perturbation is continued.

Otherwise, the direction of the perturbation is reversed. Thus, it is a continuous process of searching for the Voltage on the power Vs. Voltage (P-V) curve, which increases the power output of the P.V array [12]

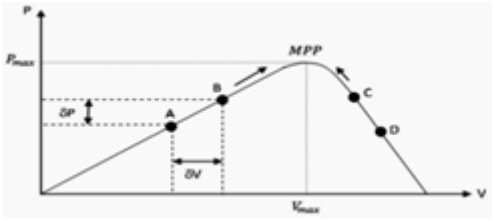

Figure 2: Description of P&O Algorithm for MPPT.

Hill Climb Search MPPT Algorithm for Wind Turbine

The HCS algorithm for MPPT control logic implementation for the wind power generation system is shown in Fig. 3.

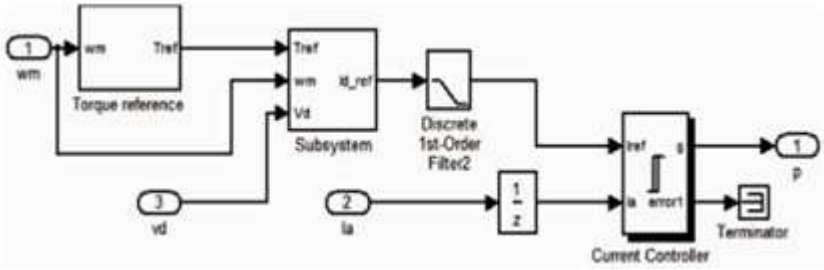

Figure 3: Sub-System Implementation of MPPT control for Wind Power System.

The inputs to the controller are Voltage, current, and speed of PMSG. 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 the boost converter, which controls the operation of wind power generation at MPP.

Voltage Regulated Inverter Design

The inverter plays a crucial role in the hybrid power generation. The load voltage, frequency is controlled and maintained consistent using an inverter in stand-alone operation. The suggested Voltage regulated. Inverter maintains the output voltage and frequency constant irrespective of change in wind speed, solar irradiation levels, and load conditions.

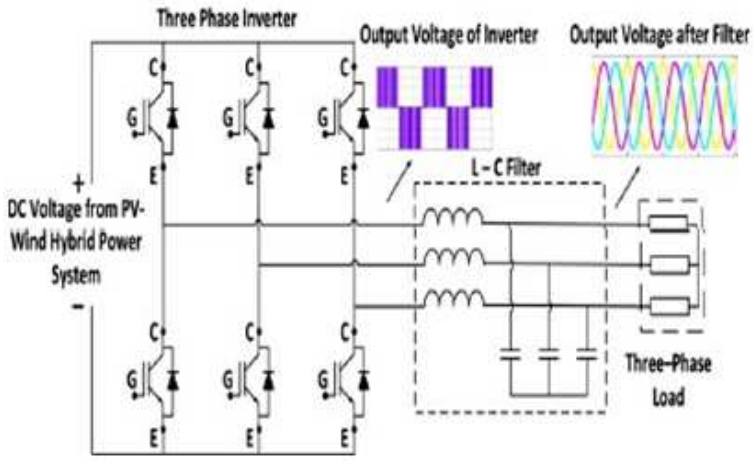

Figure 4: Power Generation of the Hybrid System under Varying Wind Speed and Radiation.

The rectified and boosted D.C. voltage from the P.V. and wind is applied as input to the inverter. The schematic diagram of Voltage regulated inverter is shown in Fig.4

MODELING AND CONTROL OF HYBRID SYSTEM

Case 1: 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.

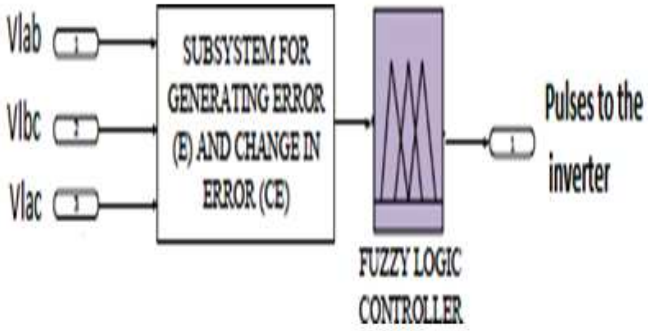

Figure 5: Block Diagram of FLC Voltage Regulated Inverter.

They are computed by considering the inverter voltage line and have been calculated as output. Fig.4 indicated the sub-system implementation of the algorithm using FLC for Voltage regulated inverter from the solar wind generation system.

The rules for the Mamdani FLC implementation are tabulated, as shown in Table.

Table 1: Rule Base for FLC Implementation

DE/ E	NL	NM	NS	Z	PS	PM	P.L.
NL	PL	PL	PL	PL	Z	Z	Z
NM	PL	PL	PM	PM	Z	Z	Z
NS	PL	PM	PS	PS	NM	NS	NM
Z	PL	PL	PS	Z	NS	NM	NL
PS	NM	PS	PS	NS	NL	NL	NL
PM	Z	Z	Z	NM	NM	NL	NL
PL	Z	Z	Z	NL	NL	NL	NL

Case-2 FNN Voltage Regulated Inverter

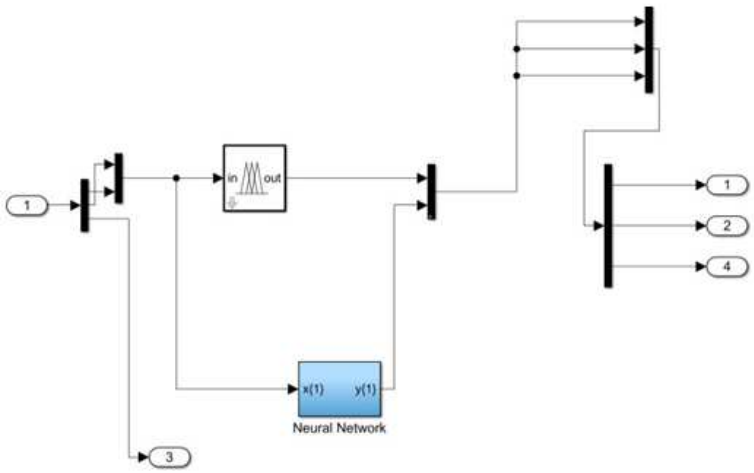

Figure 6: Block Diagram of FNN Based Controller of VSI.

PROPOSED METHOD

Fuzzy Neural Network

Fuzzy neural networks (FNN) are neural networks of fuzzy neurons. These networks have as main characteristic the synergic collaboration between the fuzzy theory and neural networks, generating models that integrate the treatment of the uncertainty and interpretability provided by fuzzy systems and the learning ability provided by neural networks[10].

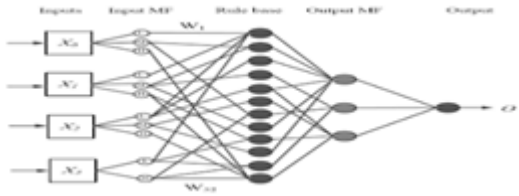

Figure 7: General Structure for FNN Controller.

SIMULATION RESULTS

The model can be designed in MATLAB/simulink and discussed with fuzzy neural network controller and fuzzy control systems. Input sources are both solar and wind.

Solar irradiation 1000(w/m2) with temperature as input source it converts electrical energy by using controlled current and voltage source blocks. Wind energy generated by the PMSG at different wind speed levels.

Battery devices are applied for energy storage purpose and it is charge and discharge when the input source is in off condition.

Observe the below figures those are generated by the fuzzy logic controller and fuzzy neural network system; the conventional method fuzzy control devices give the errors in both output voltage and current waveforms. In that time, it is observed that the total harmonic distortion (THD) increased and obtained number of power losses.

The proposed method an integrated fuzzy neural network system (AIFNN) control and remove the occurring errors and produce the clear output voltage and current wave forms compare to conventional method. An AFNN theory was better then compare to conventional fuzzy logic control method.

With Fuzzy Logic Control System Outputs

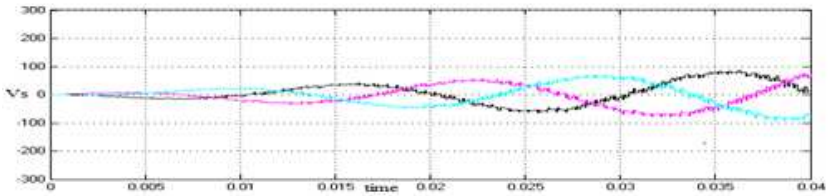

Figure 8: VSI Output Voltage Source.

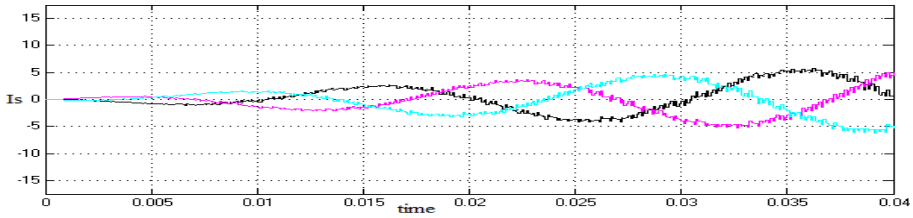

Figure 9: VSI Output Current Source.

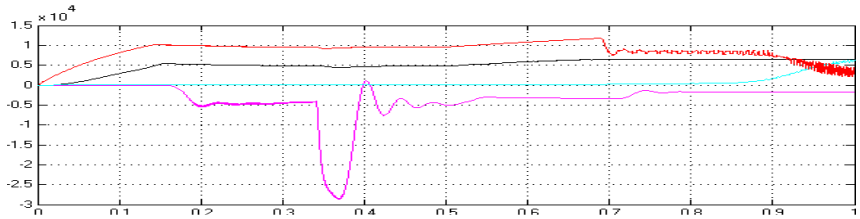

Figure 10: Power Generation of the Hybrid System under Varying Wind Speed and Irradiation.

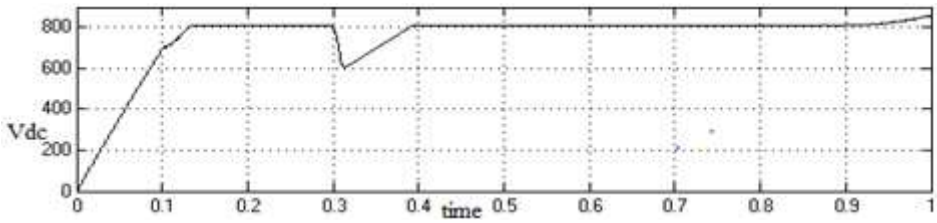

Figure 11: Vdc Voltage Source.

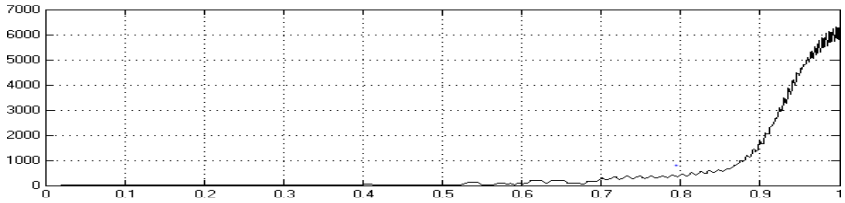

Figure 12: Wind Power.

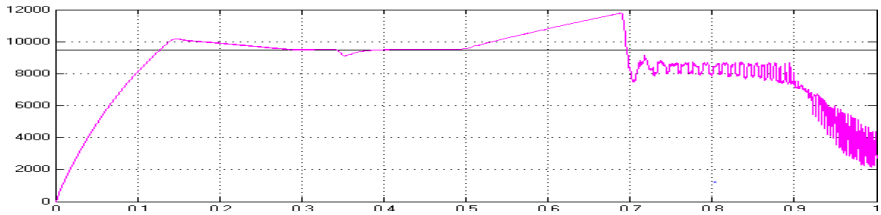

Figure 13: Wind Power.

With Fuzzy Neural Network System Outputs

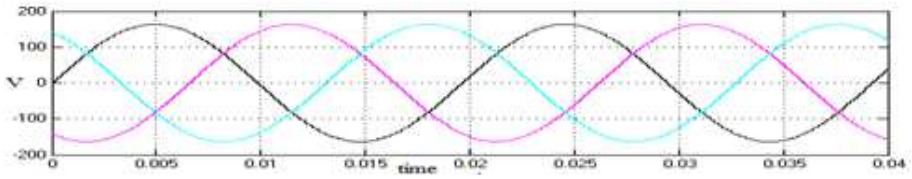

Figure 14: VSI Output Voltage Source.

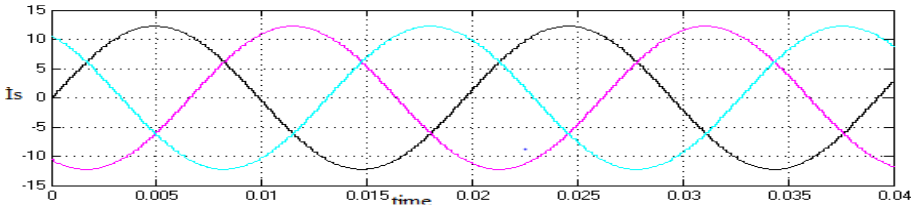

Figure 15: VSI Output Current Source.

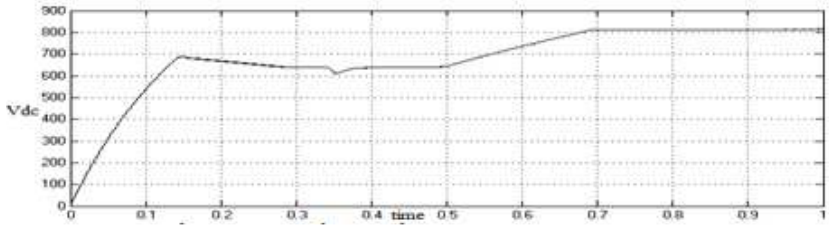

Figure 16: Vdc Voltage Source.

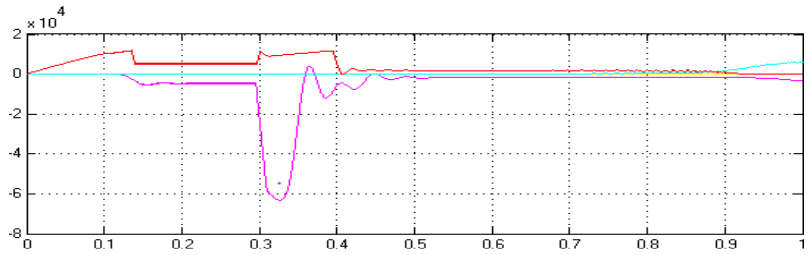

Figure 17: Power Generation of the Hybrid System Under Varying Wind Speed and Irradiation.

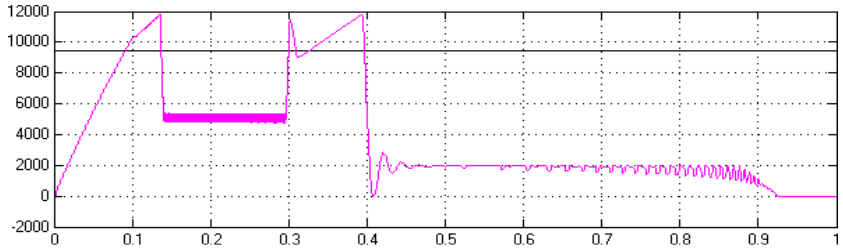

Figure 18: Solar Power with Irradiation.

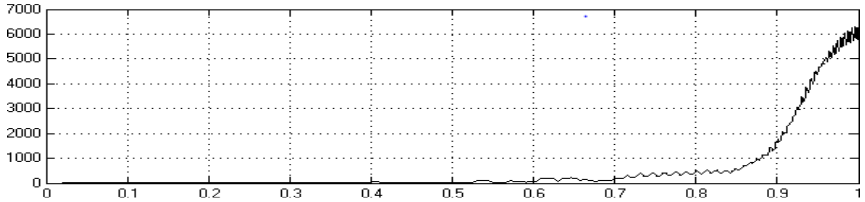

Figure 19: Wind Power.

The PV power generation branch characteristics are analysed. Fig.7 shows the voltage with MPPT controller under different irradiances. It verifies that the PV power generation branch can readily perform the MPPT and achieve the maximum output power at a given irradiance; fig 13, 14 shows the output current and voltage for the PMSG wind system with HCS algorithm MPPT controller. It can be clearly observed that the MPPT controller plays a key role in the hybrid power system.

In order to reduce the losses and to improve the efficiency and performance of the fuzzy neural hybrid system a faster MPPT controller is required. In the first case fuzzy with PI voltage regulated inverter the output voltage is unstable with disturbance in frequency compared to the AIFNN voltage regulated inverter shows in fig 5 and fig 6. The power flow in the second case provide the power efficiency and the advantage of fuzzy neural network algorithm to control the inverter and the stability of system compared to the fuzzy with PI voltage regulated inverter.

Table 2: Comparison of Fuzzy Logic Controller and Neural Network Methods

Source	Fuzzy Logic Controller	Neural Network System
	Output	Output
Voltage	120V	150V
Current	12A	15A
DC Voltage	800V	850V
Battery Voltage	820V	850V

CONCLUSIONS

Nature has provided sufficient opportunities to mankind to make best use of its resources and still maintain its attractiveness. In this context, the proposed fuzzy neural network system with hybrid PV-wind system provides an elegant integration of the wind turbine and solar PV to extract optimum energy from the two sources. It gives a compact converter system, while incurring reduced cost. The proposed controller of inverter for wind–solar hybrid system considerably improves the performance of the power system in terms of enhanced generation capability. The comparative results show the advantages of proposed controller.

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