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# Reduced Output Fluctuations of Hybrid System using SCIG by Fuzzy Logic Controller

**M.Divya, R.Vijaya Santhi**

***Abstract:*** *In this paper, the Squirrel Cage Induction Generator(SCIG) with distinct controllers to deal with a hybrid wind hydro scheme is employed. In order to reduce the output power fluctuations in SCIG, including energy storage in the battery, a fuzzy logic controller is proposed. This controller smoothens the reactive power to the supplied load by the wind generator. The proposed controller has faster convergence compared with usual PI controller under the presence of parametric variations and uncertainties. From literature, the control scheme as many controllers operates on the Proportional Integral control, which is easy to enforce and performs well under linear conditions of load. But the proposed controller operates not only linear load but also under nonlinear load conditions. Simulation results show the robustness of the proposed controller in eliminating the harmonics, efficiency and minimizing peak oscillations of the output voltage when compared with the conventional controller.*

***Keywords: Squirrel Cage Induction Generator (SCIG), hybrid wind system, fuzzy logic control (FLC).***

## I. INTRODUCTION

As the population increasing electricity generation is playing a vital role. To reduce pollution there must give attention to environmental awareness. Among renewable energy wind energy source is widely using for power generation in the power system. When electrical energy is insufficient or not easily available during that case economically wind energy can be used. For power generation, in isolated locations, a wind-hydro hybrid system is used because it has the ability to complement one another and this hybrid system generates power by using a SCIG has been stated in the literature [1]-[2]. The generator of the wind turbine is connected to the converter and the generator of the hydro turbine connected to the load. This system uses a battery that is connected between two converters on the dc bus. The benefit of using a battery system [4] is that there are no extra converters required to transfer the energy. In addition during load fluctuations, the battery maintains steady and sequential voltage, an inductor also connected so that ripples can be removed from the current of the battery.

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In parallel with the load for filtering of zero sequence load current components, a zigzag transformer
is connected. At the stator terminals, an electronic load the controller is introduced for voltage frequency control [3]. This controller transfers surplus energy from a SCIG of hydro to dump when the load is lower than the energy produced.
The Squirrel Cage Induction Generator (SCIG) is a convenient alternative for generating electricity with a wind-hydro hybrid system in distant regions with low grid connectivity. Their efficiency is higher than synchronous generators because of the advantages like robustness, brushless rotor, economical, require less maintenance, and so on. However, the inability of maintaining constant voltage and frequency is a major disadvantage of SCIG.
Most of the controllers are based on proportional-integral (PI) as they are simple for implementation and less complex. However, the PI controller cannot handle system non-linearity and require precise mathematical models to work. Fuzzy logic control (FLC) addresses these drawbacks. This work analyses and FLC- based control scheme to implement hysteresis current control for the generation of Pulse Width Modulation to control the Current-Voltage Source Inverter switches [3]. The results are compared under nonlinear load conditions with the conventional PI-based controller.

## II. PRINCIPLE OF OPERATION

There are three modes of operation is used in the hybrid system with a battery.
In the initial mode, if the load is lower than the hydro generation capacity, then the excess energy generated by the hydro is transmitted to the battery through the load-Side converter. In addition, wind energy is transmitted to the battery.
In the second mode, if the load exceeds hydro storage capacity but it is lower than the total generated power by wind and hydro. Thus, the portion of the capacity generated by wind is equipped with the load and remaining power through the side of the load converter is stored in battery [1].
In the third mode, if the load is over the full power generated by wind and hydro. The battery, therefore, provides the deficit power and the wind-generated power is equipped with the side of load converter.

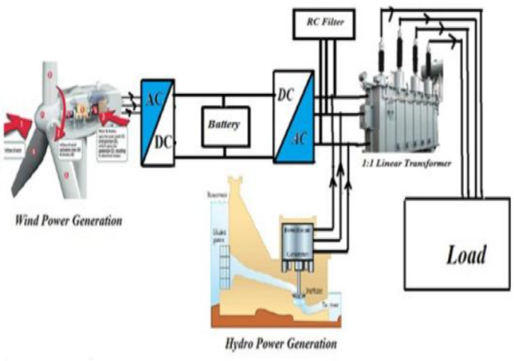



**Fig.1. schematic diagram of the wind-hydro hybrid system**

In the schematic diagram Fig 1 [2], there are two voltage source converters one is “Machine Side Converter (MSC)” and other is “Load Side Converter (LSC)”, the aim of wind turbine-powered converter of the generator side is to provide the SCIG with essential magnetizing current for wind and to achieve maximum power tracking. The converter’s aim on the load side is to regulate the load voltage magnitude and frequency. Where the control of load-side conversion is different because an active power balance must be maintained.

## III. CONTROL SCHEME FOR HYBRID SYSTEM

### A. Proportional-Integral Controller.

Proportional (P), integral (I) gains can be calculated by applying the Ziegler-Nichols method. Proportional (P) gain is to attain system stability and improved transient response. An integral part of this is to reduce the steady-state error, however, PI controllers handle nonlinearity inadequately**.** In Fig 2 is the Simulink model diagram for proportional-integral control based SCIG system, respectively.

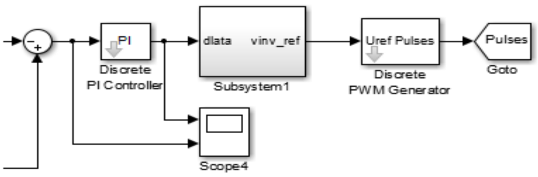



**Fig.2.Simulink Model For PI Controller**

### B. Fuzzy Logic Control

The controller's advantage is that it does not require detailed system information. This controller uses the Mamdani Fuzzy Model. These controllers have been designed to regulate and improve the transient efficiency of the power system.

Here the fuzzy controller has two inputs and a single output [5]. The membership functions of the current regulator’s input and output variables are designed. Five membership functions are considered here for accuracy. The output of fuzzy is connected to the hysteresis current regulator. The result showed better efficiency and rapid response to the proposed system. In Fig 3 the proposed block diagram of fuzzy controller is shown.

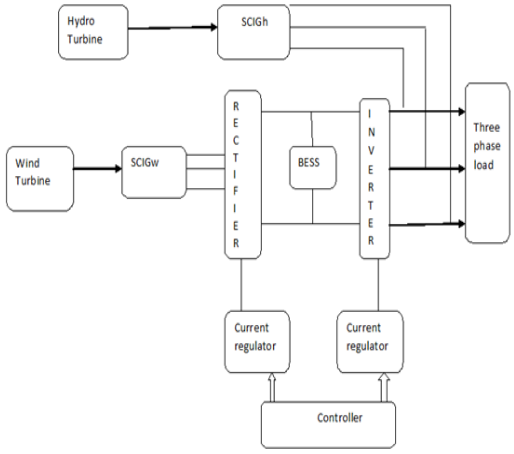



**Fig.3. Block diagram of the system proposed**

## IV. SIMULATION RESULTS

In Fig 4 the hybrid wind system simulation diagram of the Matlab is shown. The output waveforms of Load voltage ($V_L$), load current ($I_L$), $SCIG_w$ current (Isw), $SCIG_h$ current (Ish) DC link voltage ($V$dc), are shown in Figures. These graphs are hybrid systems based on fuzzy logic controller and PI controllers are analyzed for their comparison under nonlinear load conditions. For the simulation, a 55 kW,415 V, 50Hz, 6-pole squirrel cage induction generator has been used.

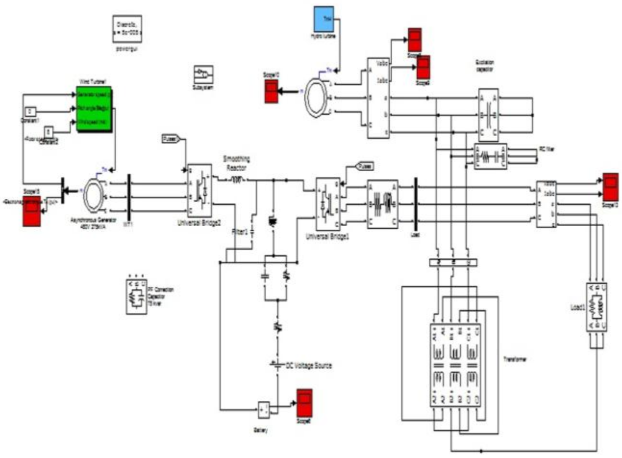


**Fig. 4. MATLAB wind-hydro hybrid simulation diagram.**

### A. Comparative assessment of Dc connect Voltage in a hybrid system.

Figures 5 and 6 show the comparison of the Dc connect Voltage in FLC and PI control for the hybrid system under the nonlinear load. The duration of the fuzzy control is lower than the pi control. At 3 sec, when the nonlinear load is connected, the Dc connect voltage linked with fuzzy control settles at approximately 3.2sec which is lesser than the settling time in PI control The results indicate that the hybrid system based on the fuzzy logic controller is superior as a voltage controller to the constant power hybrid system based on PI control

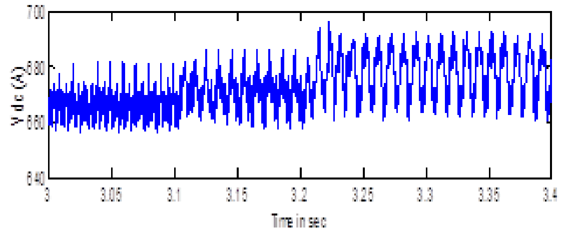



**Fig .5. Dc connect Voltage for PI controller**

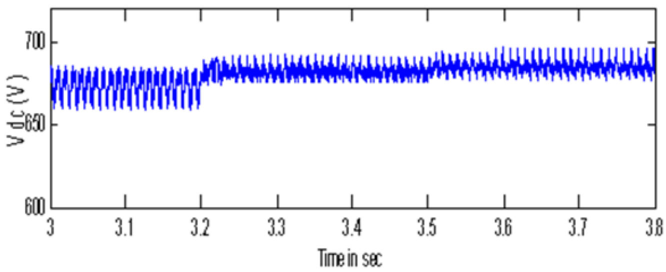
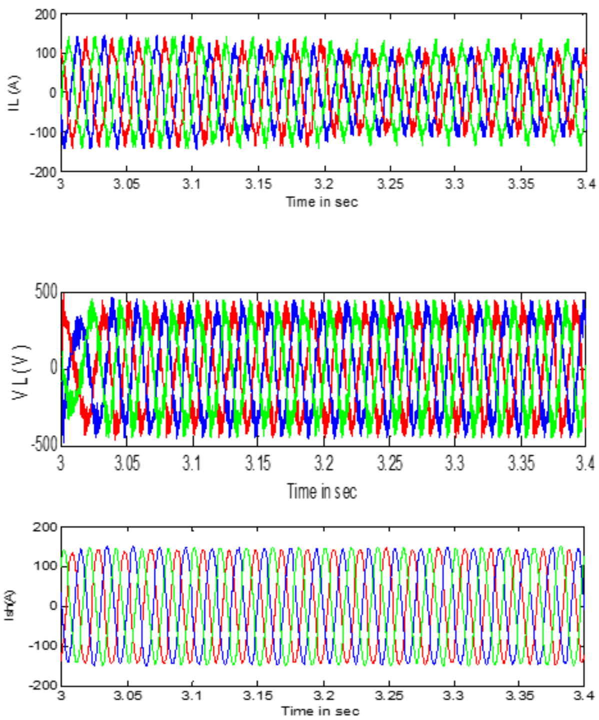



**Fig. 6. Dc connect voltage for FUZZY controller**

**B. Performance of wind-hydro hybrid system Using PI Controller Connected Nonlinear Load.**

Fig 7 shows the wind-hydro hybrid system performance based on the PI controller when connected to the nonlinear load. The load current, load voltage, stator current of hydro, stator current of wind are observed in the simulation.



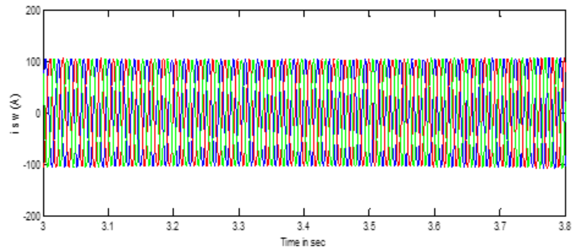
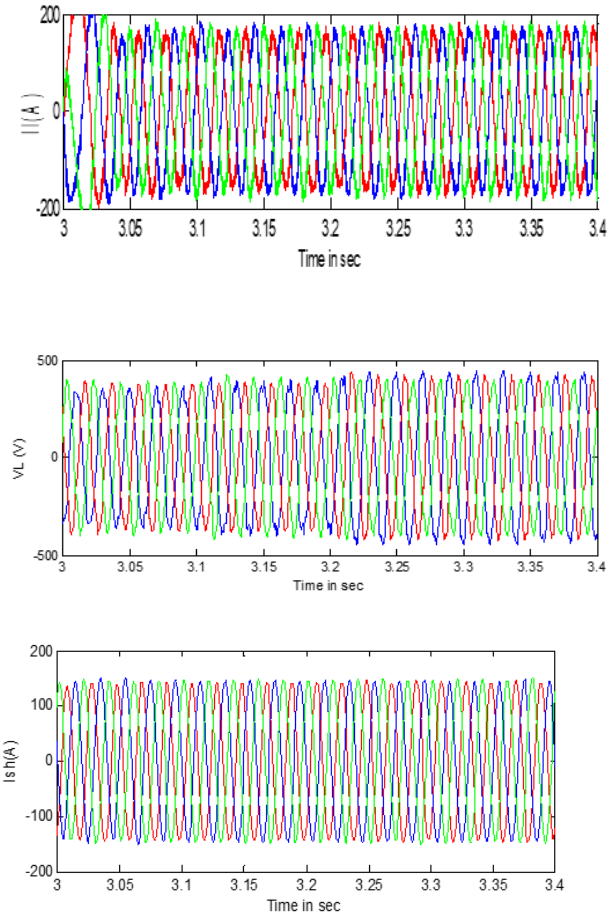




**Fig.7.With PI controller a) hybrid system load current b)hybrid system load voltage c) stator current of hydro d) stator current of wind**

**C. Performance of wind-hydro hybrid system Using Fuzzy Controller Connected Nonlinear Load.**

Fig 8 shows the wind-hydro hybrid system performance based on the FUZZY controller when connected to the nonlinear load. The load current, load voltage, stator current of hydro, stator current of wind are observed in the simulation. By using FLC these responses are superior and have fewer distortions when compare to PI controller

In Fig 9 has been shown the zoomed figure comparison of Load current. The load current THD in phases A, B, C with PI is 30.62, 22.49, 27.51 and with FUZZY controller are 25.08, 28.06, 19.47. From this result, it is shown that FLC has better performance than PI.

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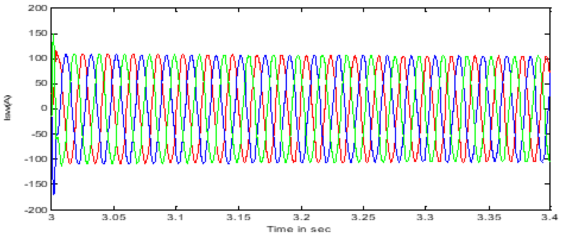
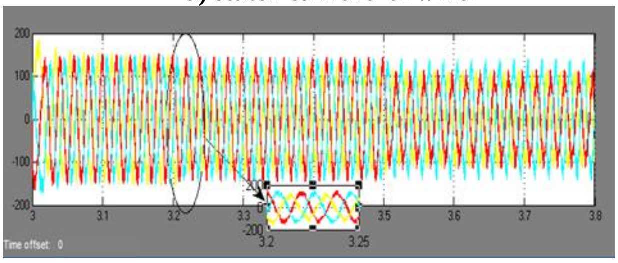



**Fig .8. With FUZZY controller a) hybrid system load current b)hybrid system load voltage c) stator current of hydro d) stator current of wind**



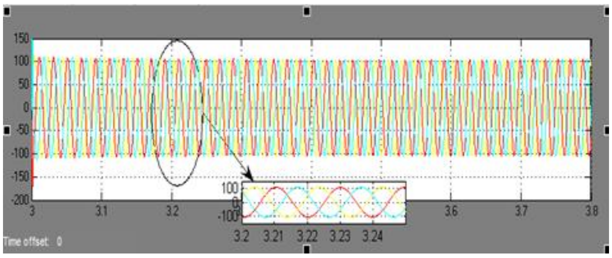




**Fig. 9. Zoomed figure of load current a)PI controller b)fuzzy logic controller**

## V. CONCLUSION

A three-phase wind-hydro with the battery storage system is designed and simulated in Matlab. The design procedure has been demonstrated for the proposed hybrid system using different controllers. The attainment of the proposed hybrid system with PI and the FUZZY controller has been demonstrated. And results show improved efficiency and fast response of the proposed fuzzy controller against the PI controller.

## REFERENCE


1. Puneet.k.Goel, Bhim Singh ''Isolated Wind–Hydro Hybrid System Using Cage Generators and Battery Storage'' IEEE Trans ON Ind. Electron, Vol.58, NO.4, APRIL 2011.
2. International Conference on Circuit, Power and Computing Technologies [ICCPCT] ''An Isolated Wind Hydro Hybrid System with Two Back- to- Back Power Converters and a Battery Energy Storage System Using Neural Network Compensator"
3. A Research Article on ''Comparative Analysis of Fuzzy Logic and PI Controller Based Electronic Load Controller for Self-Excited Induction Generator"
4. M. Black and G. Strbac, "Value of bulk energy storage for managing wind power fluctuations," IEEE Trans. Energy Convers., vol. 22, no. 1, pp. 197–205, Mar. 2007.
5. L. A. Torres-Salomao and H. Gámez-Cuatzin, "Fuzzy Logic Control and PI control Comparison for a 1.5 MW Horizontal Axis WindTurbine", *2012 16th International Conference on System Theory, Control and Computing, ICSTCC*, Control Society, Sinaia, Romania.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