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Fuzzy Based Power Quality Improves with Doubly Fed Induction Generator –Based Wind Turbines

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Abstract:- Problem of power quality is quite severe in wind energy conversion systems using induction generators. For power generation from wind induction generator are found to be the most appropriate choice. A statistical review was done to collect the data on various power quality issues like voltage variations , frequency variations, harmonics distortion , transients, flicker etc arising with the increased use of induction generator in the power system . Major problem is seen in voltage profile and frequency deviations with changing natural conditions such as wind speed and variation in load. The transient response is actually a critical dynamic characteristic of doubly fed induction generator-based wind turbines ,especially in the presence of fast transient events, such as ,for example, fault in power system .In the Fuzzy Control for the rotor side converter of these induction generator ,which is aimed to improve the transient response in relation to the dynamic performance Consider two grid fault scenarios of balanced, unbalanced voltages will be identified for Fuzzy technique.

Key Words:- Fuzzy Logic Controller, Harmonic Reduction, Power converter, Renewable Energy.

I. INTRODUCTION

Power quality (PQ) has become an important issue over the past two decades due to the relentless integration of sensitive loads in electrical power systems, the disturbances introduced by nonlinear loads, and the rapid growth of renewable energy sources[1][2]. Arguably, the most common PQ disturbance in a power system is voltage sags but other disturbances, such as harmonic voltages and voltage imbalances, may also affect end user and utility equipment leading to production downtime and, in some cases, equipment terminal damage. Inspite of many control techniques Fuzzy Logic is a control system which is based on certain logical functions and nearer to human thinking process.

The advantage of Fuzzy Logic Controller over other controller is it does not require mathematical model unlike other controllers used for linear systems[3]. It can handle nonlinearity and can be of more robust. When compared to PI controllers Fuzzy Logic system is more efficient for nonlinear networks i.e., it minimizes harmonics and improves the quality of power. Adaptiveness cannot be achieved in the operation of fuzzy logic[5][7]. Difficulties in tuning the PI and NFC can be achieved by using NFC which act as a tuned estimator. The proposed system is implemented with Variable Speed Wind Turbine (VSWT) which is more contrast than constant speed wind turbine as the power extraction is less when compared to variable speed wind turbine, so the power fluctuations can be avoided also maximum power can be obtained at variable speed condition. WECS is connected directly to the grid and hence the power supply to the grid must be of balanced one as the grid should be maintained at unity power factor, hence to provide grid synchronization.

II. DFIG WIND TURBINE

The use of Doubly Fed Induction Generator is more advantage as the supply to the AC mains can be from both stator and rotor as the stator is connected to the AC mains whereas rotor is connected to the control system which may be of PI and NFC. Normally PI controllers are suitable for linear systems where as FLC is for nonlinear systems even though the distortion in harmonics is reduced for both linear and nonlinear network by PI and FL controllers, the output of which is not much efficient when compared to NF controller, which can be seen while comparing FL and NF controllers[9]. Figure 1 shows the block diagram of WECS, which consist of, DFIG, interconnections and FL controller .IGBT is utilized as interconnections to control the power at unbalanced conditions. The converter which is connected at the grid side is used for the compensation of real and reactive power flow hence the cost of using APF is reduced.

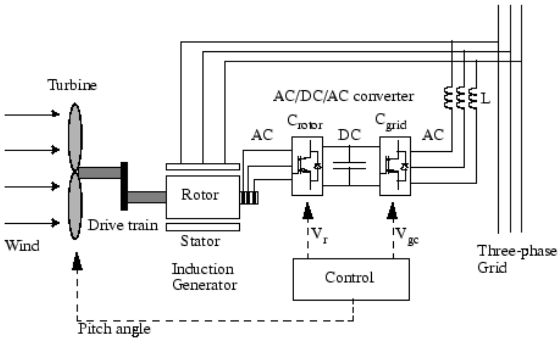

Fig.1 DFIG Wind Energy Conversion System

The power control is mainly done by power converters (IGBT). The switching loses obtained due to power converters are controlled by Fuzzy Logic Controllers.

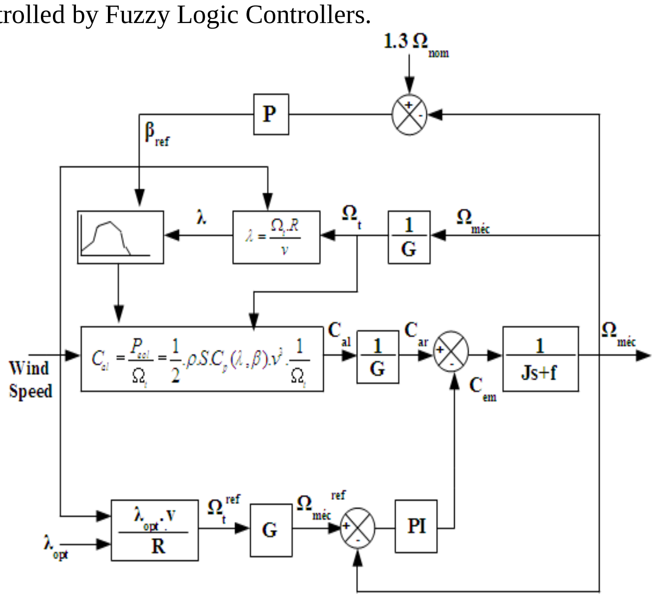

Figure .2 Scheme of the speed control of DFIG

III. FUZZY LOGIC CONTROL

Fuzzy Logic is based on logical functions. The concept of Fuzzy logic is derived from set theory[10]. There are several controllers which provide efficient control for linear systems. In case of nonlinear systems Fuzzy Logic Controllers are used. Fuzzification, rule creation, and defuzzification are the steps involved in fuzzy logic system. The input to the fuzzy controller is in the form of real variables. In the process of fuzzification the real variables are converter into fuzzy variable and each fuzzy variable are represented by membership function. The second step is

Formation of fuzzy rules, fuzzy rules are based on definite decision i.e., in the form of IF-THEN. Finally when all the operations of control is over at the last stage the fuzzy variables are again converted into real variables which is as known defuzzification.

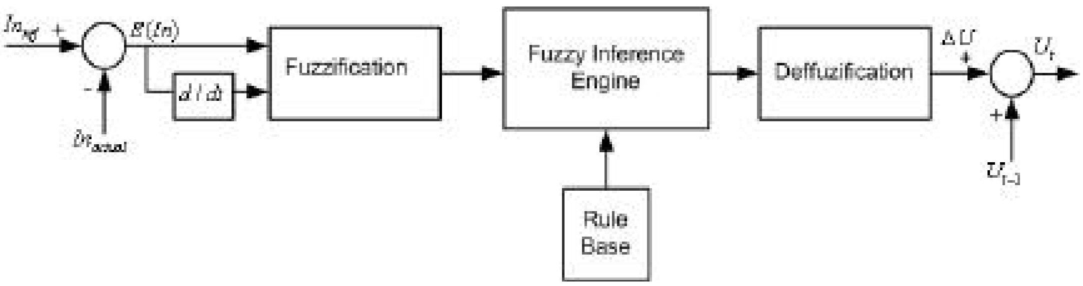

Fig. 3 Block diagram of fuzzy controller

IV. THE WECS USED FOR SIMULATION

In order to analyze the advantage of fuzzy method to control the doubly-fed induction generator in wind energy conversion system, the overall system is simulated using Mat lab Simulink software. The Wind Energy conversion system taken for simulation shown in fig.8 consists of a 6 MW Wind farm using four 1.5 MW doubly fed induction generators [11], [12].

The voltage generated by the wind farm is stepped up to 25 KV using a three phase transformer unit. The power is then transmitted over a 15 KM transmission line and a three phase step up transformer unit to the grid. The designed system consists of a 2-MVA plant consisting of a 1.68MW induction motor load along with a 200-kW resistive load at bus B25.

The rotor side converter control system and the grid side converter control system of the above system uses PI controllers. The dynamic behavior of the above system for different faults such as line to ground fault, line to line fault, double line to ground fault and symmetric fault are studied and the graphs of the generated, real power, reactive power and the wind speed are presented in the figure[13]. The PI controllers of the above system are replaced by fuzzy logic controller.

In proposed system based on fuzzy logic controller, some different situations and events are considered. Based on different fault locations and severity, the system has different responses. In each condition, many different parameters such as wind speed, voltage, active and reactive power and etc are shown to prove the capability of the proposed controller.

The simulation results of the dynamic behavior of the system with fuzzy controllers are presented .A comparison of the results shows that the system with the fuzzy controller is able to recover from all the faults except symmetrical fault.

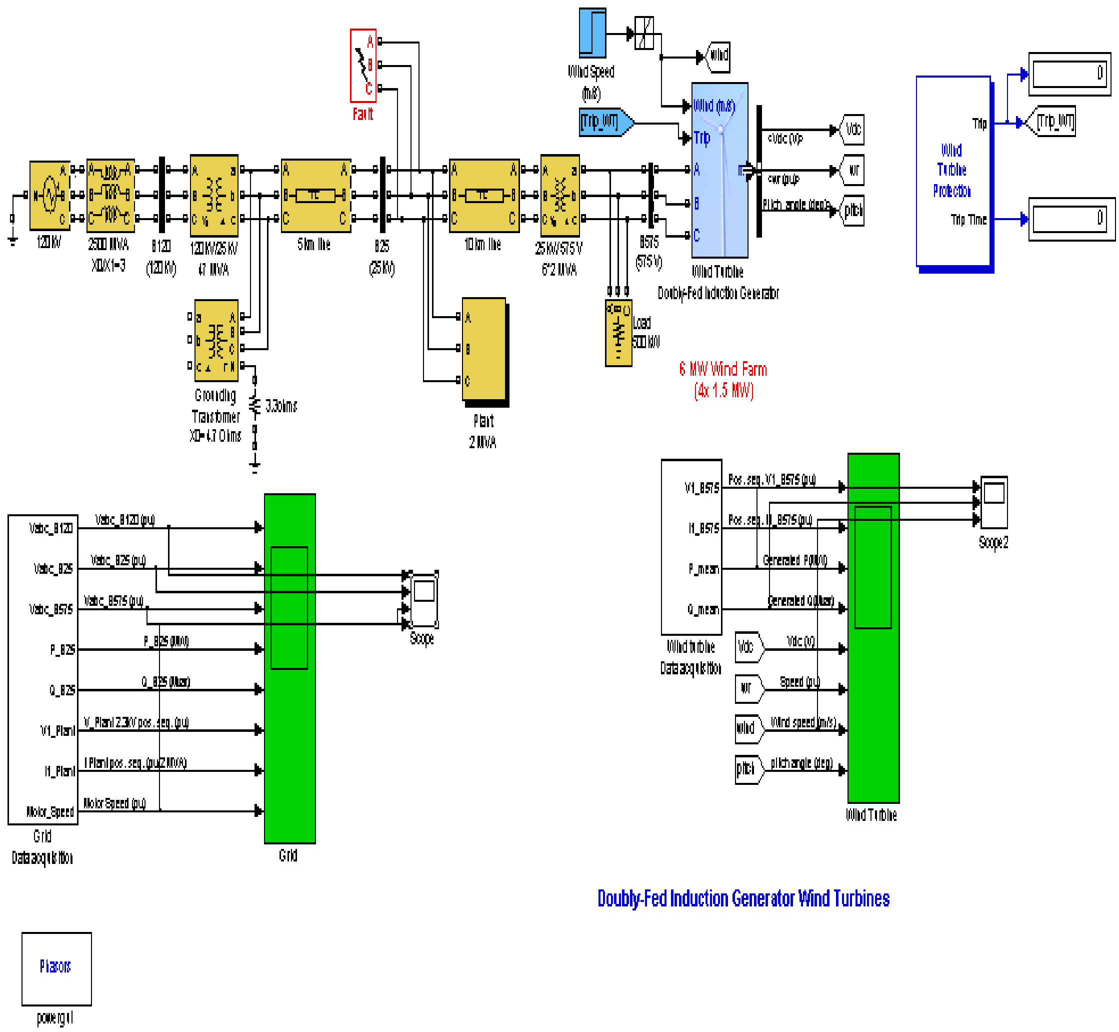

Fig.4 Doublefed induction generator wind turbine

V. SIMULATION RESULTS

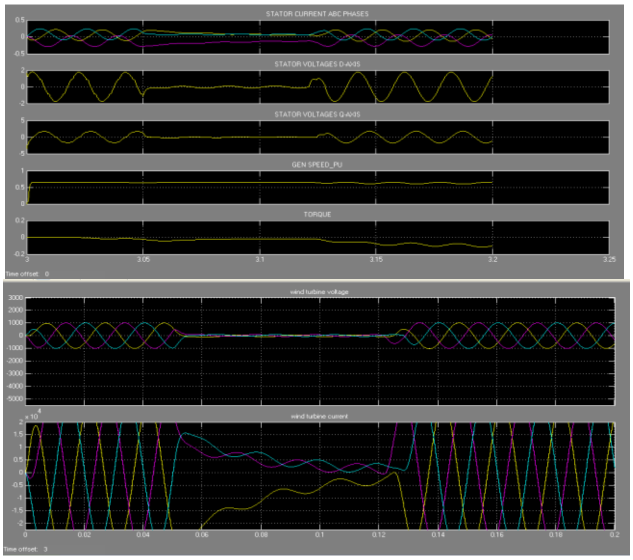

Fig. 5 Simulation of responses to fault without controller

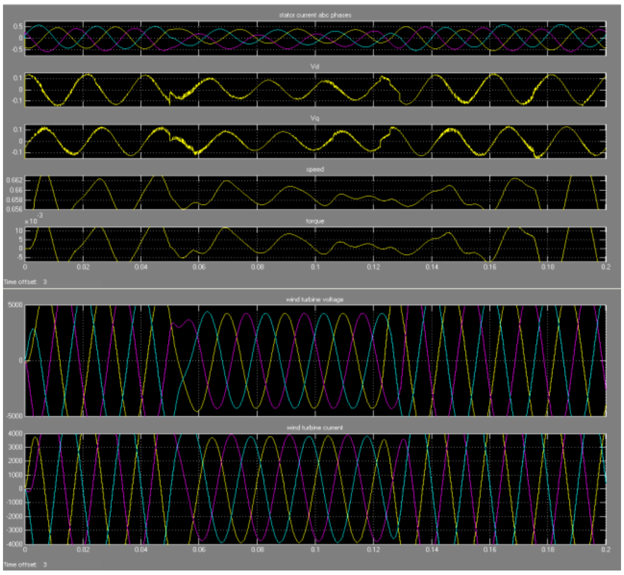

Fig. 6 Simulation of responses to fault with controller

It is seen that when fault occurs, there are disturbances in stator current and stator voltage as shown in fig.5 when there is no controller. As against this, with fuzzy controller, the disturbances in stator current and voltage are reduced as shown in fig.6. It is seen that the controller is able to reduce disturbances in all relevant parameters [14].

VI. CONCLUSION

This paper investigates fuzzy logic control of DFIG wind turbine. For this purpose a user defined block is used. All parameters and structures such as study system, wind turbine and control unit are described in details. To prove the performance of controller unit, different abnormal situations are exerted. Closer fault location to the wind turbine causes more severe situation and a three line to ground short circuit fault near the wind turbine as the worst case is studied in which voltage decreases until about zero and rotor current exceeds its limit. Crowbar switch as protection unit disconnects the rotor side converter and reconnect it after a constant time delay.

After fault clearance, both electrical and mechanical control units using emergency pitch angle restore all parameters to their predefined values as soon as possible. Excellent performance of fuzzy logic controller using on-line tuning of parameters based on any situation maintains stability and improves power quality of wind turbine.

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