

New Photo Voltaic Solar Based Flexible AC Transmission System (FACTS) Devices

N.Sivakumar¹, D.Marry Jeyanchi², M.Gopi³

Professor and Head, Jayalakshmi Institute of Technology, Tamil Nadu, India¹

Assistant Professor, Jayalakshmi Institute of Technology, Tamil Nadu, India²

PG Scholar, Jayalakshmi Institute of Technology, Tamil Nadu, India³

ABSTRACT: This paper presents detailed analysis to compare the performance of wind turbine under asymmetric faults using static compensator with PI and Fuzzy logic controller. A static compensator control structure is used to compensate the positive and negative sequence voltage compensation under different fault conditions as the negative sequence voltage causes heavy torque oscillations that reduces the life of the drive train. Simulations have been carried out with PI controller and fuzzy logic controller based STATCOM in Matlab/Simulink. comparative analysis has been carried out for the direct quadrature control strategy of different asymmetric faults and analyze the direct and quadrature axis of current and voltage, torque, speed, active and reactive power. The fuzzy logic controller gives better performance than PI under asymmetric faults and suppresses the torsional oscillations thereby improving the overall performance of the system.

KEYWORDS: Fixed Speed Induction Generator, Wind Turbine, Fuzzy Logic Controller, Static compensator.

I. INTRODUCTION

The wind power penetration has increased dramatically in the past few years, hence it has become necessary to address problems associated with maintaining a stable electric power system that contains different sources of energy including hydro, thermal, coal, nuclear, wind, and solar. In the past, the total installed wind power capacity was a small fraction of the power system and continuous connection of the wind farm to the grid was not a major concern. With an increasing share derived from wind power sources, continuous connection of wind farms to the system has played an increasing role in enabling uninterrupted power supply to the load, even in the case of minor disturbances. The wind farm capacity is being continuously increased through the installation of more and larger wind turbines[1]. Voltage stability and an efficient fault ride through capability are the basic requirements for higher penetration. Wind turbines have to be able to continue uninterrupted operation under transient voltage conditions to be in accordance with the grid codes. Grid codes are certain standards set by regulating agencies. C.Nagarajan et al [2,5,8] has studies Wind power systems should meet these requirements for interconnection to the grid. Different grid code standards are established by different regulating bodies [2] but Nordic grid codes are becoming increasingly popular. One of the major issues concerning a wind farm interconnection to a power grid concerns its dynamic stability on the power system. Voltage instability problems occur in a power system that is not able to meet the reactive power demand during faults and heavy loading conditions. Stand alone systems are easier to model, analyze, and control than large power systems in simulation studies. A wind farm is usually spread over a wide area and has many wind generators, which produce different amounts of power as they are exposed to different wind patterns. but the fixed speed induction generators have a poor reactive power capability when compared to doubly fed induction generator[3]. Although different types of FACTS controllers are available, UPQC and STATCOM have a good fault mitigation capability.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 9, Issue 3, March 2020

II. WIND TURBINE FIXED SPEED INDUCTION GENERATOR

A. Grid Connected Induction Generator

Grid connected induction generators develop their excitation from the Utility grid. The Generated power is fed to the supply system when the IG is run above synchronous speed. Machines with cage type rotor feed only through the stator and generally operate at low negative slip. But wound rotor machines can feed power through the stator as well as rotor to the bus over a wide range known as Doubly Fed Induction Machines [4]

B. Fixed Speed Grid Connected Wind Turbine Generator

The structure and performance of fixed-speed wind turbines as shown in Fig.1 depends on the features of mechanical sub-circuits, e.g., pitch control time constants etc.

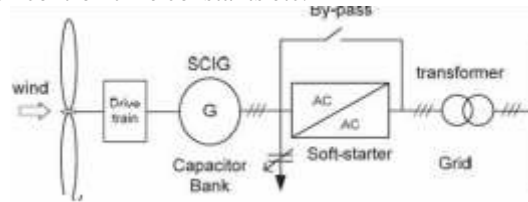


Fig : 1 Fixed Speed Wind Turbine With Directly Grid Connected Squirrel - Cage Induction Generator

The reaction time of these mechanical circuits may lie in the range of tens of milliseconds. As a result, each time a burst of wind hits the turbine, a rapid variation of electrical output power can be observed[3]. These variations in electric power generated not only require a firm power grid to enable stable operation, but also require a well-built mechanical design to absorb high mechanical stress, which leads to expensive mechanical structure, especially at high-rated power[7].

III. STATIC COMPENSATOR (STATCOM)

The basic electronic block of the STATCOM is the voltage source inverter [5] that converts an input dc voltage into a three-phase ac output voltage at fundamental frequency. These voltages are in phase and coupled with the ac system through the reactance of the coupling transformer. Suitable adjustment of the phase and magnitude of the STATCOM output voltages allow effective control of active and reactive power exchanges between the STATCOM and the ac system. The first transformer is in Y-Y connection and the second transformer is in Y- connection. The first transformer is step down and the second one is step up transformer. The IGBT of the proposed STATCOM is internally fed to dq reference frame and DSOGI-PLL which is used to separate the positive sequence and negative sequence voltages and currents[8].

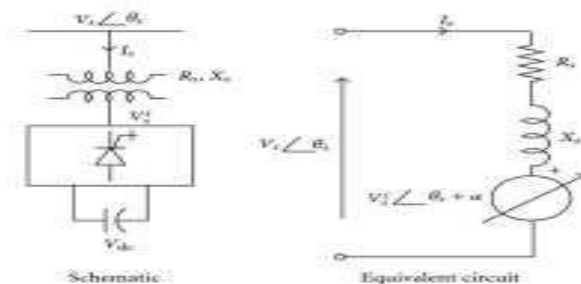


Fig 2. STATCOM Structure

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 9, Issue 3, March 2020

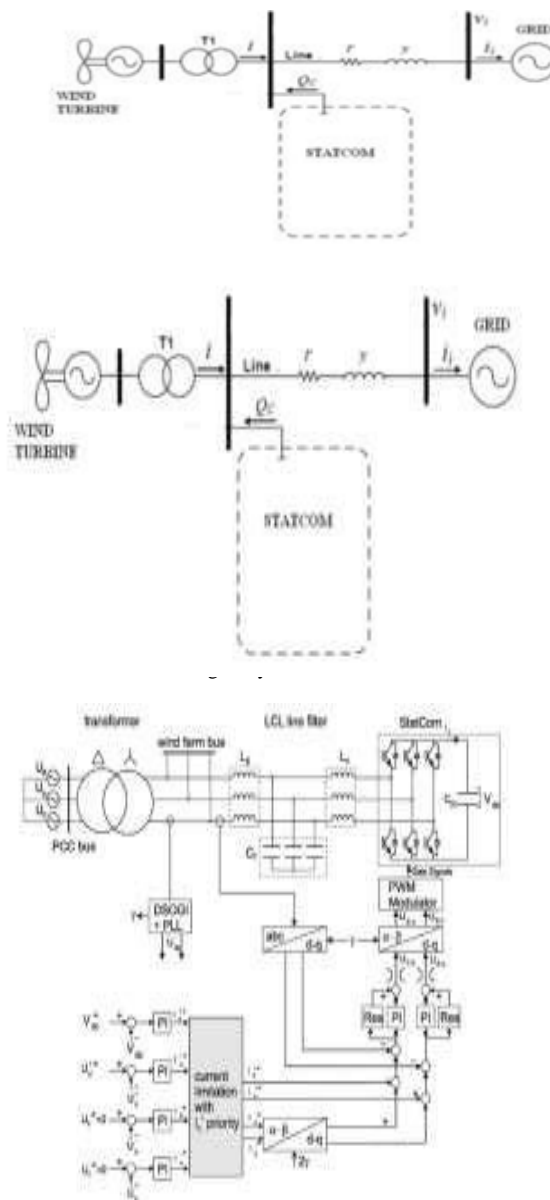


Fig:4: STATCOM Control Structure

IV. FUZZY LOGIC CONTROLLER

The control system is based on fuzzy logic. This type of control, approaching the human reasoning that makes use of the tolerance, uncertainty, imprecision and fuzziness in the decision-making process, manages to offer a very satisfactory performance, without the need of a detailed mathematical model of the system, just by incorporating the experts knowledge into fuzzy[4].The fuzzy logic control system is based on mamdani fuzzy model. This system consist four main components. First, using input membership functions, inputs are fuzzified

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 9, Issue 3, March 2020

then based on rule bases and inference system, outputs are produced and finally the fuzzy outputs are defuzzified and applied to the

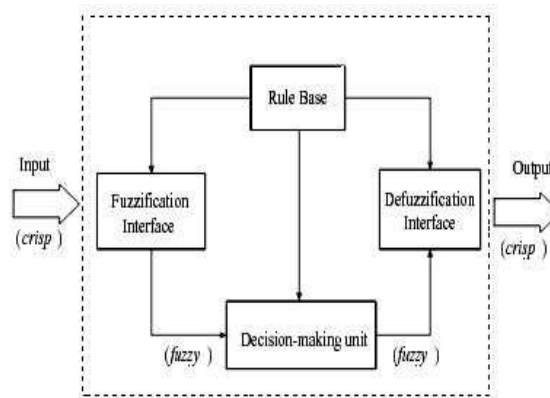
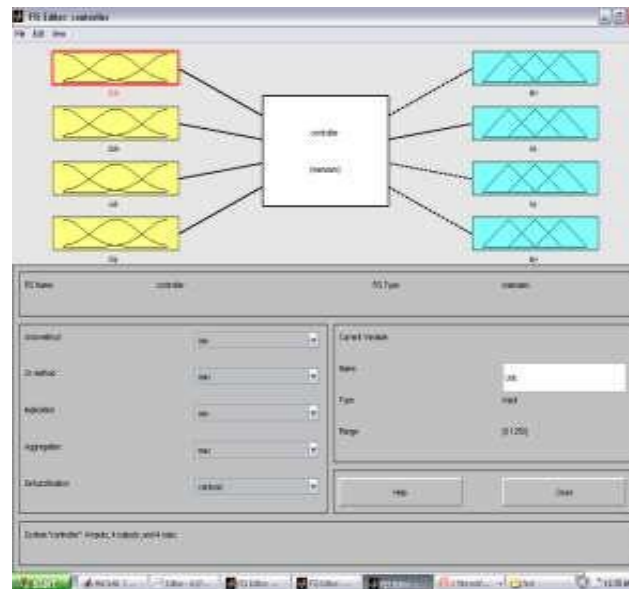


Fig:5 : Block Diagram of fuzzy logic controller

STEP1: SELECTION OF INPUT AND OUTPUT VARIABLES



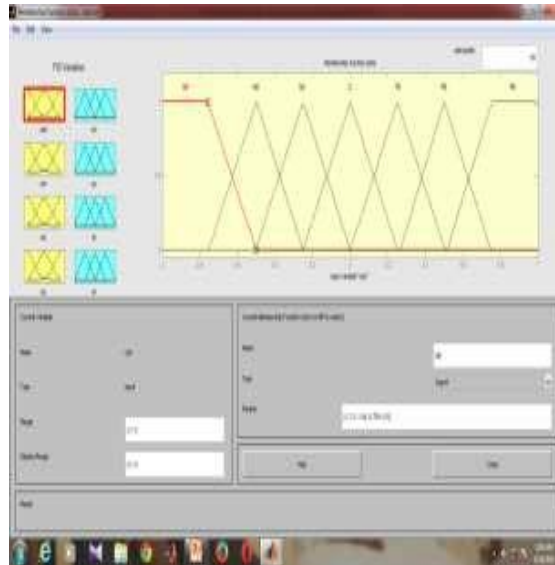
STEP2: ASSIGNING MEMBERSHIP FUNCTIONS

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 9, Issue 3, March 2020



STEP3: RULE TABLE

e Δe	<i>NB</i>	<i>NM</i>	<i>NS</i>	<i>Z</i>	<i>PS</i>	<i>PM</i>	<i>PB</i>
<i>NB</i>	<i>NB</i>	<i>NB</i>	<i>NB</i>	<i>NB</i>	<i>NB</i>	<i>NM</i>	<i>Z</i>
<i>NM</i>	<i>NB</i>	<i>NB</i>	<i>NB</i>	<i>NM</i>	<i>NS</i>	<i>Z</i>	<i>PS</i>
<i>NS</i>	<i>NB</i>	<i>NB</i>	<i>NM</i>	<i>NS</i>	<i>Z</i>	<i>PS</i>	<i>PM</i>
<i>Z</i>	<i>NB</i>	<i>NM</i>	<i>NS</i>	<i>Z</i>	<i>PS</i>	<i>PM</i>	<i>PB</i>
<i>PS</i>	<i>NB</i>	<i>NS</i>	<i>Z</i>	<i>PS</i>	<i>PM</i>	<i>PB</i>	<i>PB</i>
<i>PM</i>	<i>NS</i>	<i>Z</i>	<i>PS</i>	<i>PM</i>	<i>PB</i>	<i>PB</i>	<i>PB</i>
<i>PB</i>	<i>Z</i>	<i>PS</i>	<i>PS</i>	<i>PB</i>	<i>PB</i>	<i>PB</i>	<i>PB</i>

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 9, Issue 3, March 2020

V. SIMULATION RESULT

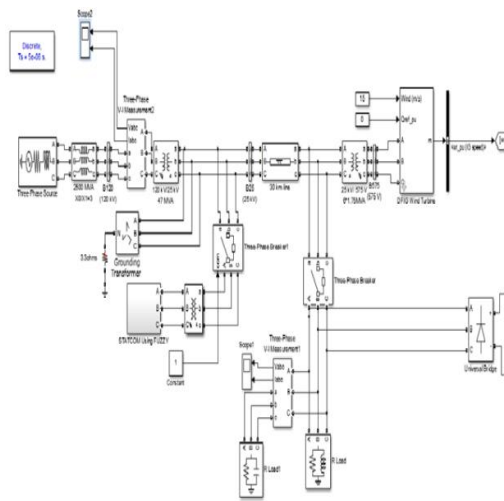
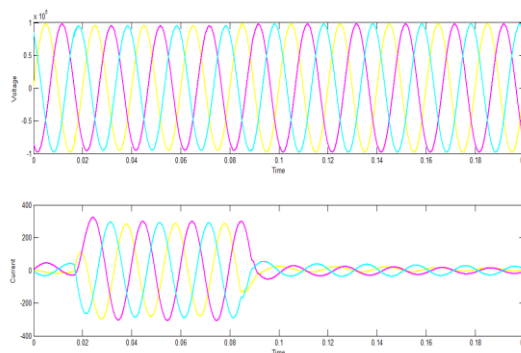


Fig 6. Simulation

Figure 6. shows the simulation block where in wind farm use wound- rotor induction generator is connected to the grid side. STATCOM and three phase load(both linear and non- linear) are connected across the transmission line. In STATCOM used fuzzy based rules. Here, Evaluating Grid voltage and current, load voltage and current and FFT analysis.

VI. RESULT



International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 9, Issue 3, March 2020

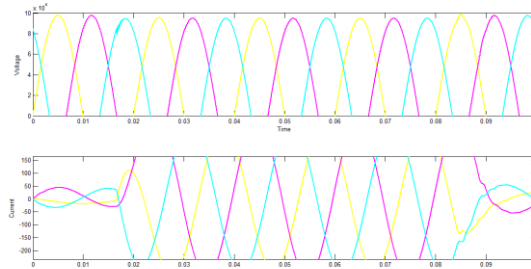


Figure 7. GRID Voltage and Current

Figure 7. shows the grid side voltage and current, switching time of three phase breaker is about $[1/60 \text{ } 5/60]$.The current wave form is works according to the time interval. While starting to current waveform there is some harmonics detected in the voltage waveform and end of the switching time current waveform are deviated from the wave

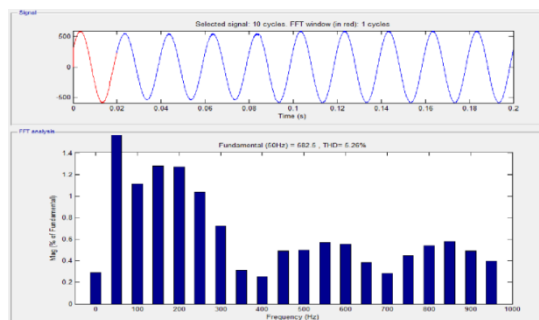


Figure 8 Fundamental Frequency and Harmonics (THD) with STATCOM

Figure 8. FFT analysis with discrete system with STATCOM fuzzy controller. While using STATCOM the Fundamental Frequency=58.5 and Harmonics(THD)=5.62%.while using PID controller the Fundamental Frequency=1024 and Harmonics(THD)=7.36%

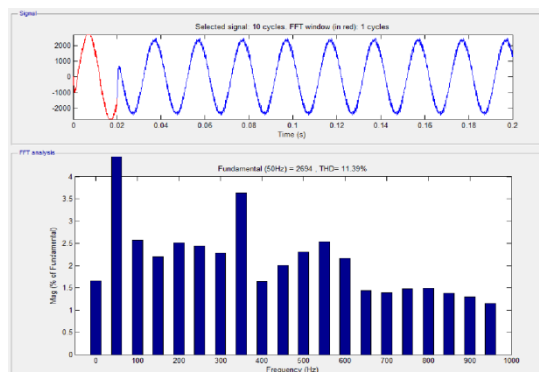


Figure 6.4 Fundamental Frequency and Harmonics(THD)without STATCOM

Figure 6.4, FFT analysis with discrete system without STATCOM fuzzy controller. The Fundamental Frequency=2694 and Harmonics (THD)= 11.36%

Figure 6.5 load voltage and current, described by the switching time of three phase breaker

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 9, Issue 3, March 2020

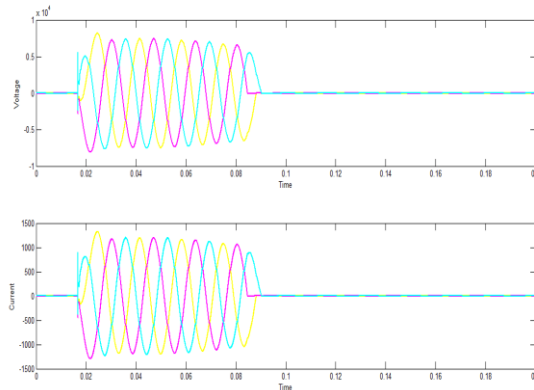


Figure 6.5 Load Voltage and Current

VII. CONCLUSION

The fuzzy logic controller is implemented and compared with PI fed vector control for wind turbine fed FSIG under different asymmetric faults using STATCOM. It is observed that the settling time and peak overshoot is reduced considerably in fuzzy logic based controller. Hence Fuzzy logic controller surpasses the traditional PI control during non-linear variations and it gives better performance than PI in wind turbine fed FSIG under different asymmetric faults.

REFERENCES

- [1] M.Loserre, R.Cardenas, M.Molinas and J.rodiguez, "overview of multi-MW wind turbines and wind parks," IEEE Trans. Ind. Electron, vol. 58 no.4.1018-1095, apr.2011
- [2] C.Nagarajan and M.Madheswaran - 'Stability Analysis of Series Parallel Resonant Converter with Fuzzy Logic Controller Using State Space Techniques'- *Electric Power Components and Systems*, Vol.39 (8), pp.780-793, May 2011
- [3] Christian wessels, Marta Molinas "StatCom control at wind farms with fixed- speed induction generators using asymmetrical grid faults," IEEE trans ind. Electronics, vol. 60, no. 7, july 2013
- [4] M. Tsili and S. Papathanassiou, "A review of grid code technical requirements for wind farms," IET Renewable Power Gener., vol. 3, no. 3, pp. 308–332, Sep. 2009
- [5] E Geetha, C Nagarajan, "Induction Motor Fault Detection and Classification Using Current Signature Analysis Technique", 2018 Conference on Emerging Devices and Smart Systems (ICEDSS), 2nd and 3rd March 2018, organized by mahendra Engineering College, Mallasamudram, PP. 48-52, 2018
- [6] Jon Are Suul, Molinas, "STATCOM- Based indirect torque control of induction machined during voltage recovery after grid faults," IEEE trans Power Electron. VOL25.NO.5, May 2010
- [7] Mikhail.N.Slepchenkov, Keyue Ma Smedley, "Hexagram- Converter-Based STATCOM for Voltage support in Fixed- Speed Wind Turbine Generation system," IEEE trans ind. VOL 58, no4 April 2011
- [8] J.C. Nagarajan, M.Madheswaran and D.Ramasubramanian- 'Development of DSP based Robust Control Method for General Resonant Converter Topologies using Transfer Function Model'- *Acta Electrotechnica et Informatica Journal* , Vol.13 (2), pp.18-31, April-June.2013
- [9] N.Hoffmann, L.Asiminoaei, and F.W. Fuchs, "Online grid-adaptive control and active- filter functionality of PWM- converters to mitigate voltage unbalance and voltage-harmonics a control concept based on grid impedance measurement," in Proc.IEEE ecce, Sep.2011. pp. 3067-3074