International Journal For Technological Research In Engineering
Volume 7, Issue 7, March-2020 *ISSN (Online): 2347 - 4718*

SIMULATION OF UPQC CUSTOM POWER DEVICE FOR POWER QUALITY ENHANCEMENT USING PI & FUZZY CONTROLLER

Ms. Naazneen Sipai[1], Mr. Jatin A. Patel[2]
[1]P.G. Scholar, [2]Assistant Professor,
Electrical Department, Merchant Engineering College, Basna, Visnagar, Gujarat, India

Abstract: Compare to other renewable energy sources solar and wind energy sources are the fastest-growing type of renewable energy sources. While we consider the wind power for electricity generation constant power generation is very necessary for any grid connection in the power system. The integration of wind farms with the power grid leads to Power Quality (PQ) issues such as voltage sag, swell, flicker, harmonics, etc. Most of the industrial and commercial loads are of non-linear type which indeed the starting place of harmonics. As 70% of PQ problems are voltage sag which is one of the most severe disturbances to sensitive loads. As an outcome of the aforementioned issues, both consumer sector and the production sector gets affected with poor quality of power which urges PQ enhancement at its best level. Among many of custom power devices, Unified Power Quality Conditioner (UPQC) is the only device used to diminish both voltage sag and current harmonics. This project analyzes PQ problems, voltage sag and current harmonics due to the interconnection of grid-connected wind turbines and also provides PQ enhancement by introducing UPQC. To improve the performance of UPQC, a novel control strategy using Fuzzy Logic Controller (FLC) is proposed which eliminates the drawback of using fixed gains in conventional PI controller. The simulation of proposed system of Wind power plant connected with grid using UPQC has been carried out in Matlab-Simulink.
Keywords—UPQC, PQ, PI, FLC, WindFarm,etc.

I. INTRODUCTION

A rapid development of wind power generation has been seen in a global scale. As with increasing the size of wind turbines and wind farms, a large amount of wind power is injected to the power system. Due to random nature of wind energy a huge penetration of power may cause important problems and affect the characteristics of the wind generators. The consolidation of wind energy into present existing power system creates technical challenges, which require consideration of stability, voltage regulation related power quality problems. The power quality problems can be seen in accordance to wind generation, transmission and distribution system, such as voltage sag, flickers, voltage swells, harmonics etc. Due to change in voltage, flicker and harmonics failure of devices like microprocessor-based controller, programmable logic controller (PLC), variable speed drives, light source flickering and screen occurs [1]. It also may cause to tripping of contactor, failure of protection device, sensitive equipments stoppage like computers, programmable logic control (PLC) system and may halt the process or even may damage of some sensitive equipments. In transmission and distribution system power quality of supply is very importance measure to be considered. So, considering in wind generation system this power quality issues become so much important measure. As the technology developing in the power generation field the wind power generation developing very quickly. To reduce the disturbances produced by variation in wind flow [2], we use induction generator and connect it directly to the grid system. This induction generator is simple and robust in construction and having reactive power for excitation. However, in induction generators to produce magnetization the reactive power support is required. The major drawback in induction generators is active, reactive power and the terminal voltage varies due to fluctuating wind. A sophisticated control scheme requires in wind generation system when operating normally making proper control of active power production. The new technology in wind generation system use UPQC based control scheme for improvement of the quality of power. Additionally, the wind flow is unpredictable in nature so if there is some disturbance occurs the battery energy storage system (BESS) mitigate the fluctuation of power into the system.

As an outcome of the aforementioned issues, both consumer sector and the production sector gets affected with poor quality of power which urges PQ enhancement at its best level. Among many of custom power devices, Unified Power Quality Conditioner (UPQC) is the only device used to diminish both voltage sag and current harmonics. This project analyzes PQ problems, voltage sag and current harmonics due to the interconnection of grid-connected wind turbines and also provides PQ enhancement by introducing UPQC. To improve the performance of UPQC, a novel control strategy using Fuzzy Logic Controller (FLC) is proposed which eliminates the drawback of using fixed gains in conventional PI controller. The simulation of proposed system of Wind power plant connected with grid using UPQC has been carried out in Matlab-Simulink.

The major drawbacks of any FACTS device with energy storage system(ESS) is that the size of storage system, likely battery energy storage system(BESS), may become too large and bulky for practical large-scale transmission applications. The other problem with battery system is that if numbers of cells are connected in series it results in voltage instability. But on other side if storage system is used then a large oscillation can be minimize only by injecting a small amount of power. So as the combination of a UPQC and BESS becomes an ideal controller for many types of power quality issues like voltage fluctuation, oscillation damping etc. Also, it has capability of controlling active, reactive power production independently so that it is best suited for stabilization of any kind of power disturbances occurs in power system.

II. PROBLEM IDENTIFICATION AND OBJECTIVES

The power system liberation, along with generation shortage and transmission restriction, has modified the grid conditions by providing space for energy storage devices and its new developed technology performing very important role in bettering power quality and system reliability. The benefits of such storing devices are that it can damp oscillations rapidly, reduces sudden load transients and maintain continuity of supply while a load interruption occurs in transmission or distribution system. The small size energy storing device used in wind generation system can give rated power for very short duration of time and would capable to reduce short term voltage disturbance and so improving power quality. But if there is larger energy reserve connected with wind farm then it can give power certain amount of power for longer duration of time. This increases the availability of power form wind farm and allows shutdowns for smaller stand by units at peak load time. By some means if the size of energy reserve can increase then it allows to make standby some of larger power plants which justify the investment on the whole system.

The integration of wind farms with power grid leads to Power Quality (PQ) issues such as voltage sag, swell, flicker, harmonics etc. Most of the industrial and commercial loads are of non-linear type which indeed the starting place of harmonics. As 70% of PQ problems are voltage sag which is one of the most severe disturbances to sensitive loads. As an outcome of the aforementioned issues both consumer sector and production sector gets affected with poor quality of power which urge PQ enhancement at its best level. Among many of custom power devices, Unified Power Quality Conditioner (UPQC) is the only device used to diminish both voltage sag and current harmonics. This project analyzes PQ problems, voltage sag and current harmonics due to the interconnection of grid connected wind turbine and also provides PQ enhancement by introducing UPQC. To improve the performance of UPQC, a novel control strategy using Fuzzy Logic Controller (FLC) is proposed which eliminates the drawback of using fixed gains in conventional PI controller.

III. OVERVIEW OF CONTROLLING

In this work the performance of UPQC is enhanced by developing a novel control strategy using FLC. The benefits of FLC over the conventional controller are that FLC even works without a perfect mathematical model. Also FLC is capable of handling nonlinearity and is more robust compared to conventional PI controller which also improves the performance of UPQC. The control strategy used in this work is described below.

A. Conventional PI Control strategy

In this control strategy, both shunt and series APF in UPQC is controlled with conventional PI controller as shown in fig.1. And fig.2. The gain values P and I are chosen as Kp=0.1 and Ki=2 using trial and error method. In series APF, the faulted sag voltage is compared with the reference voltage. The error voltage is processed through PI controller and its output is converted to three phase through unit vector generation, then it is fed into Pulse Width Modulation (PWM) generator to provide gate pulses to Series APF such that this can be able to inject the required voltage for the mitigation of voltage sag.

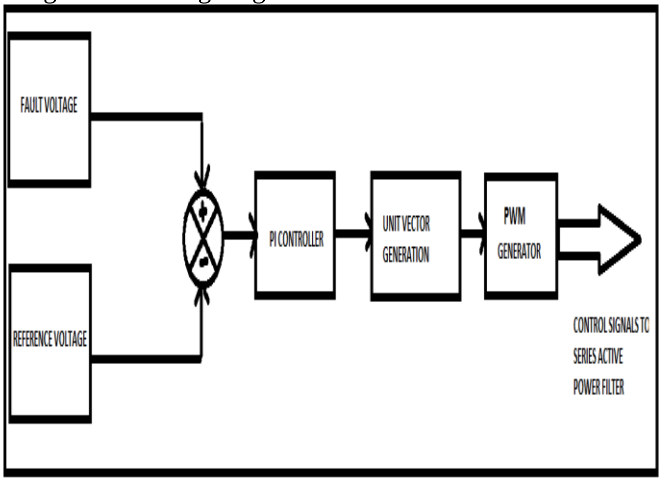

Fig.1 Control strategy for Series APF of UPQC

In Shunt APF, the harmonic load current is compared with the reference current and the error is processed through PI controller. Its output is converted to three phase and it is fed into PWM generator for providing gate pulses to Shunt APF which is capable of mitigating load current harmonics.

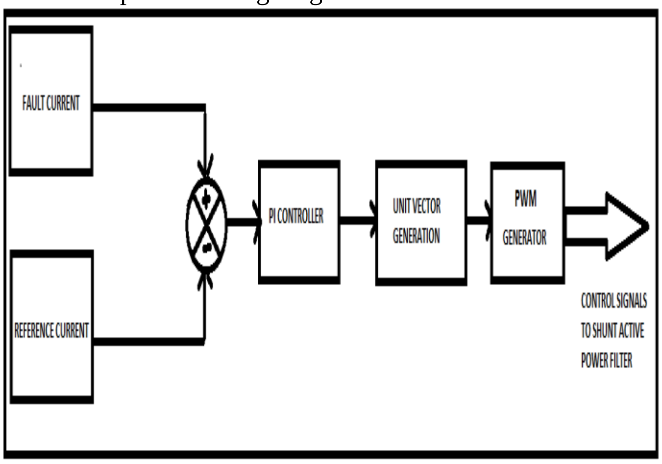

Fig.2 Control strategy for Shunt APF of UPQC

B. Fuzzy Logic Controller

FLC is one of the most successful operations of fuzzy set theory. Its chief aspects are the exploitation of linguistic variables rather than numerical variables. FL control technique relies on human potential to figure out the systems behaviour and is constructed on quality control rules. FL affords a simple way to arrive at a definite conclusion based upon blurred, ambiguous, imprecise, noisy, or missing input data. The basic structure of an FLC is represented in Fig.3.

 ISSN (Online): 2347 - 4718

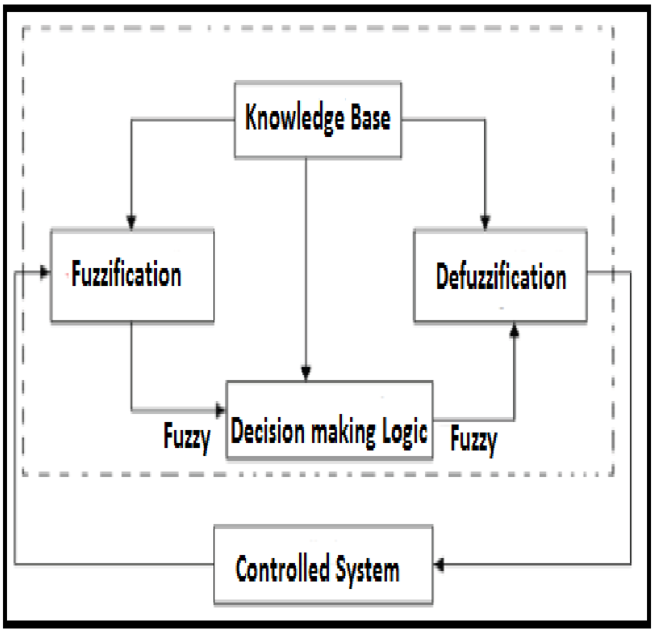

Fig.3. Basic structure of Fuzzy Logic controller

- A Fuzzificaton interface alters input data into suitable linguistic values.
- A Knowledge Base which comprises of a data base along with the essential linguistic definitions and control rule set.
- A Decision Making Logic which collects the fuzzy control action from the information of the control rules and the linguistic variable descriptions.
- A Defuzzification interface which surrenders a non-fuzzy control action from an inferred fuzzy control action.

In this project, an advanced control strategy, FLC is implemented along with UPQC for voltage correction through Series APF and for current regulation through Shunt APF. Error and Change in Error are the inputs and Duty cycle is the output to the Fuzzy Logic Controller as shown in Fig. 4-Fig.5.

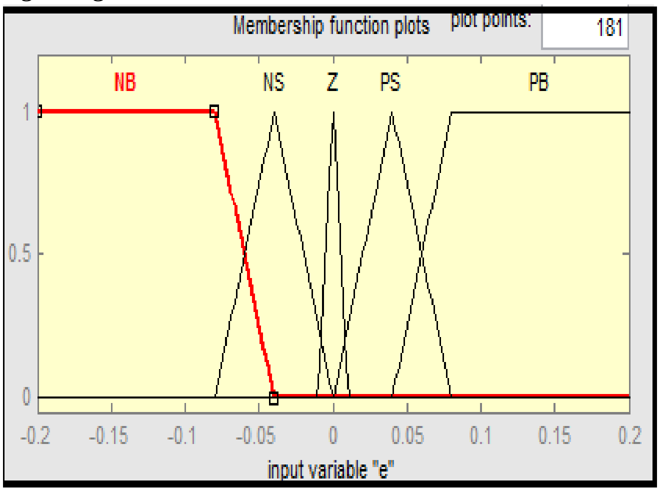

Fig.4 Error as input

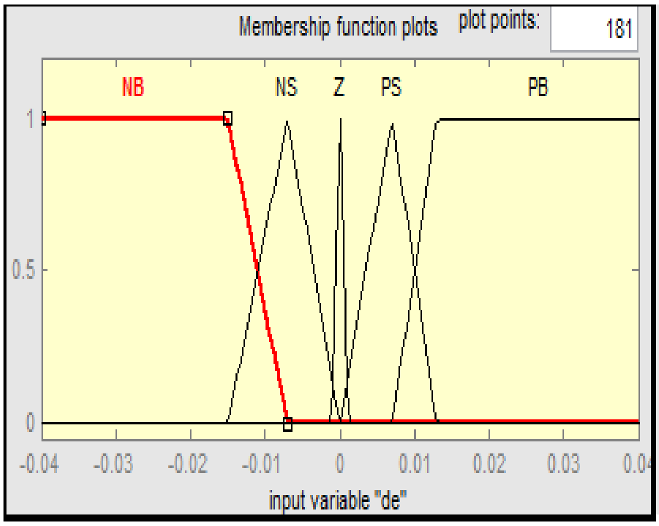

Fig.5 Change in Error as input

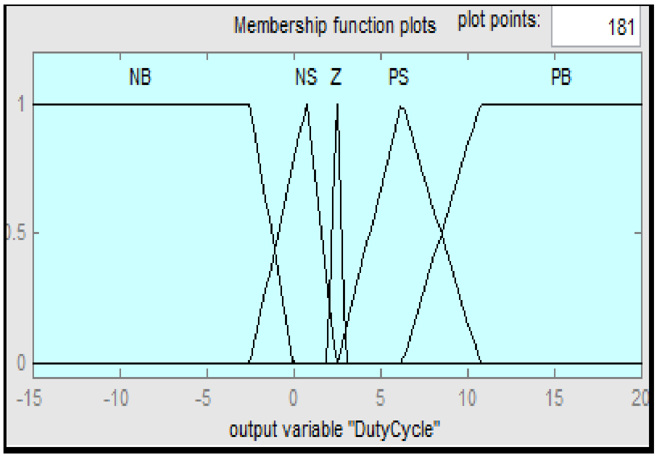

Fig.6 Output variables to defuzzification process

IV. SIMULATION AND RESULT DISCUSSION

In the below section the UPQC device has been integrated with proposed wind power plant and DFIG system and the voltage profile improvement and the power control also shown in the simulation results.

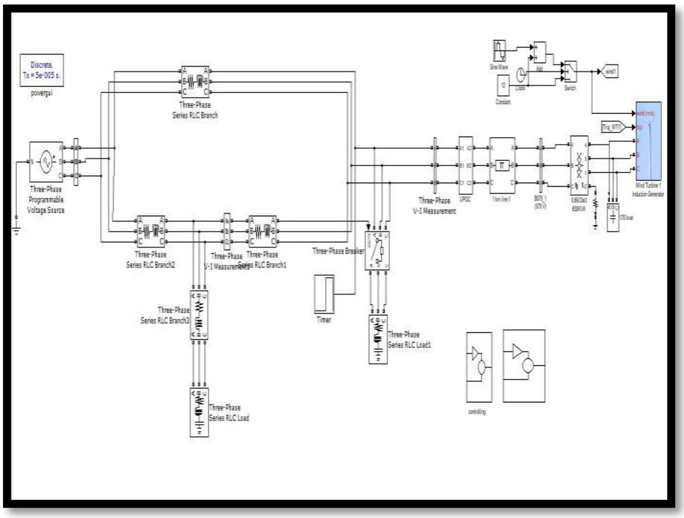

Fig 7- Proposed system with UPQC

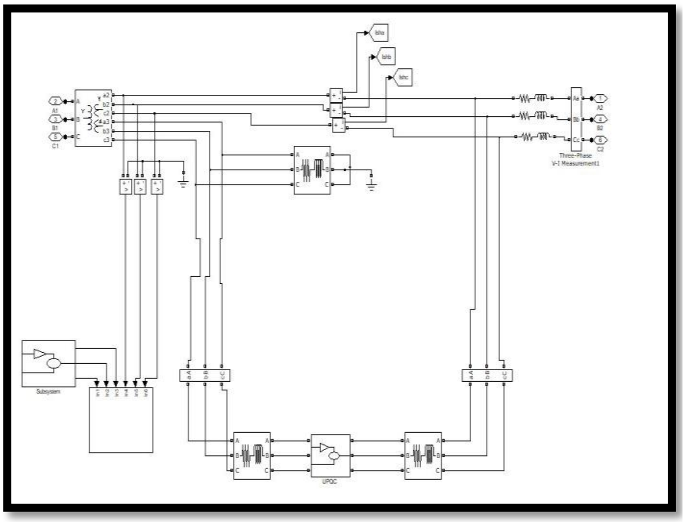

Fig 8-UPQC Control subsystem

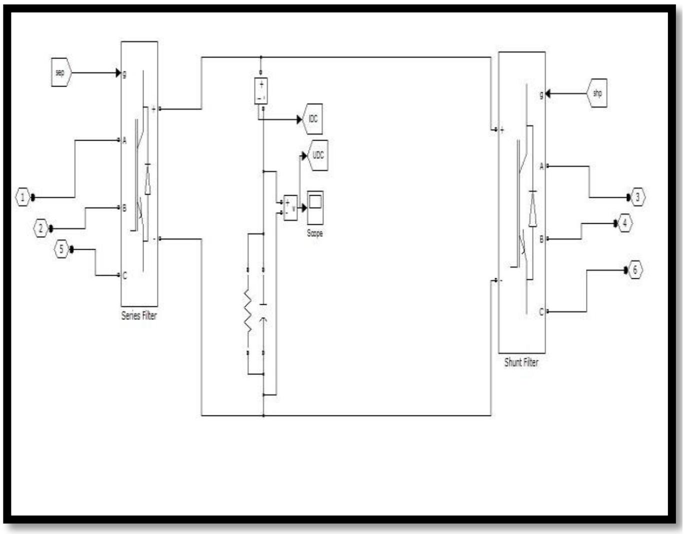

Fig 9- UPQC Converter subsystem

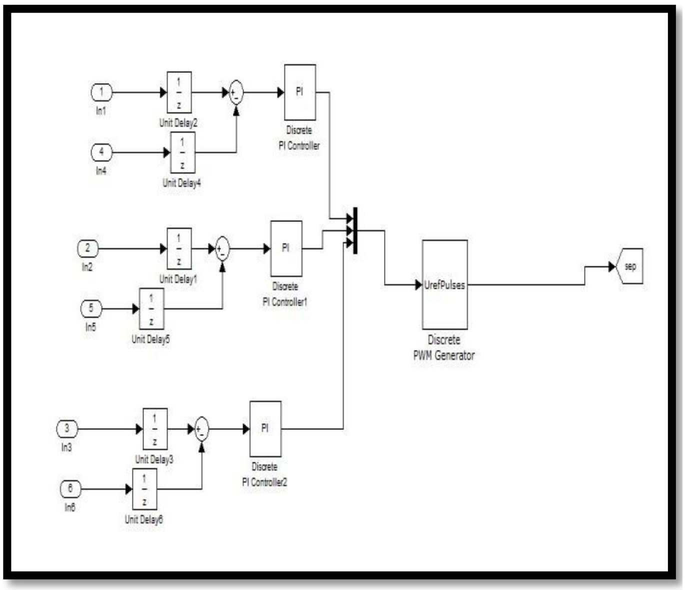

Fig 10- Series VSC triggering pulse control system

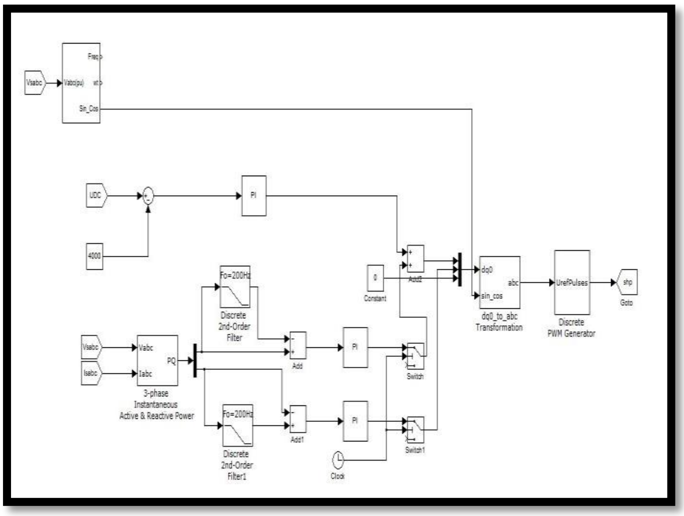

Fig 11- Shunt VSC triggering pulse control system

SIMULATION RESULTS WITH UPQC

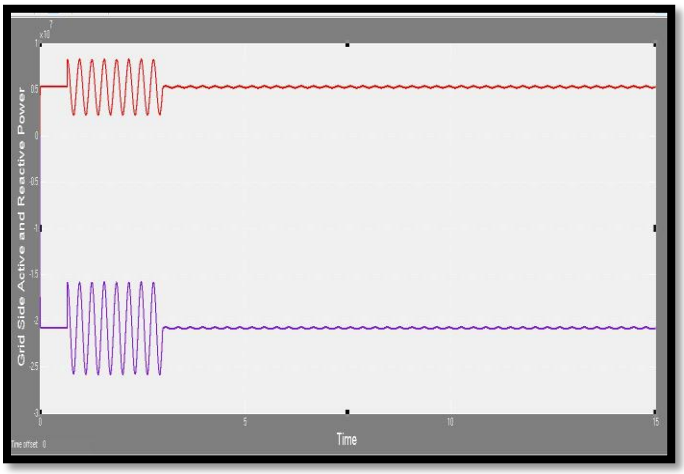

Fig 12- Grid Side Active and Reactive Power control using UPQC

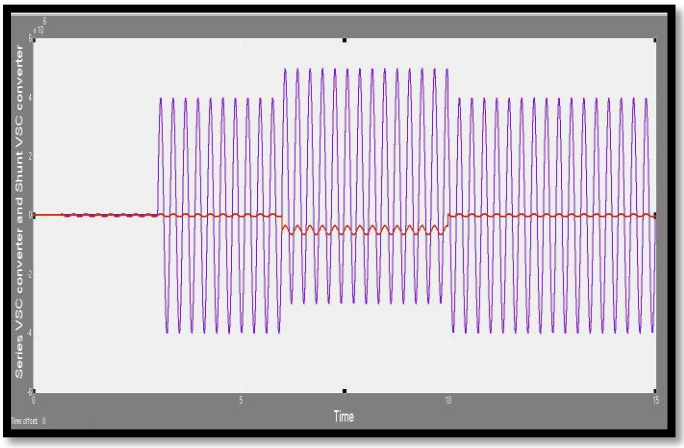

Fig 13- Series VSC controller and shunt VSC converter voltage variation

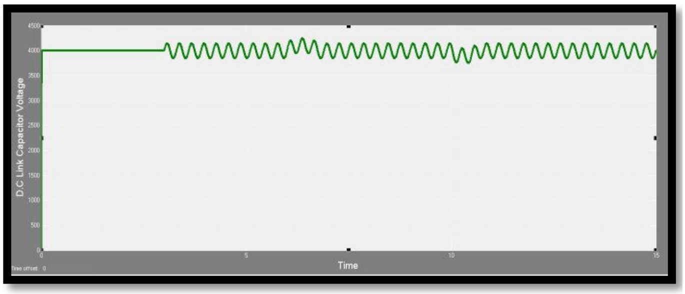

Fig 14- Common D.C link Capacitor voltage

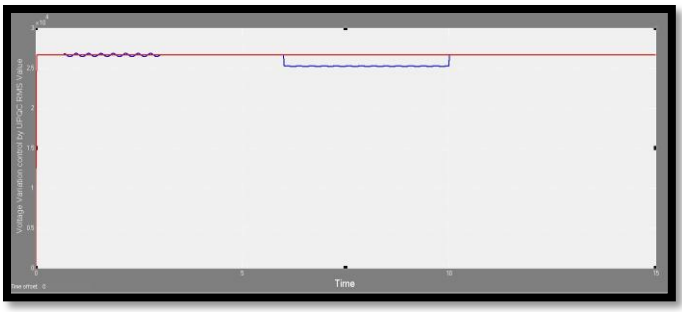

Fig 15- Voltage RMS value variation and controlling by UPQC device

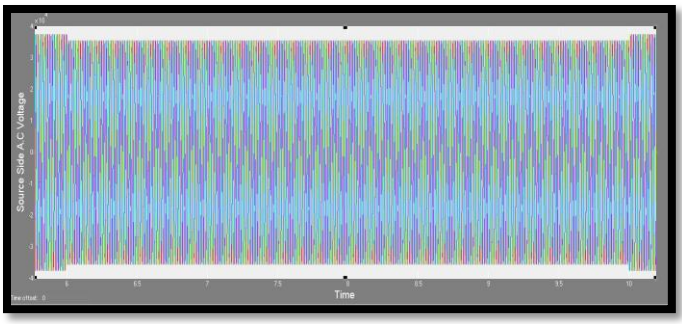

Fig 16- Source Side A.C Output Voltage

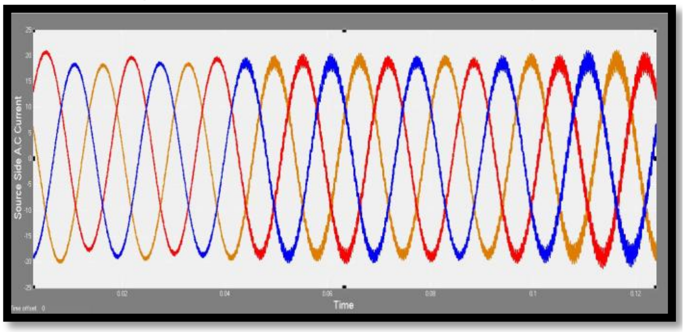

Fig 17- Source Side A.C output current

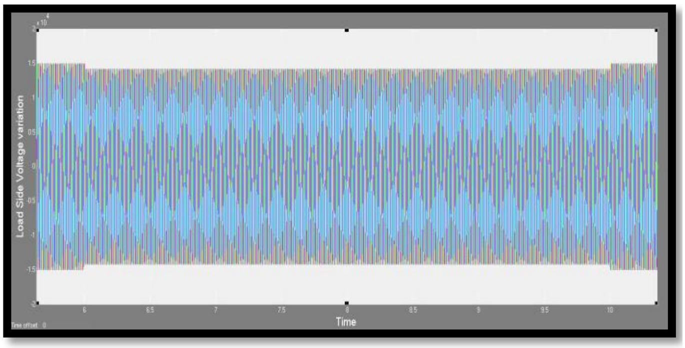

Fig 18- Load side A.C voltage

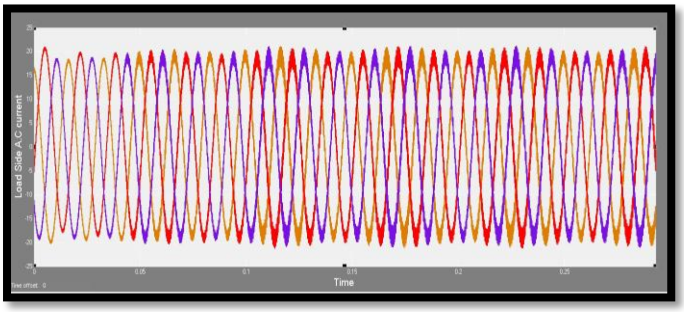

Fig 19- Load side A.C Current

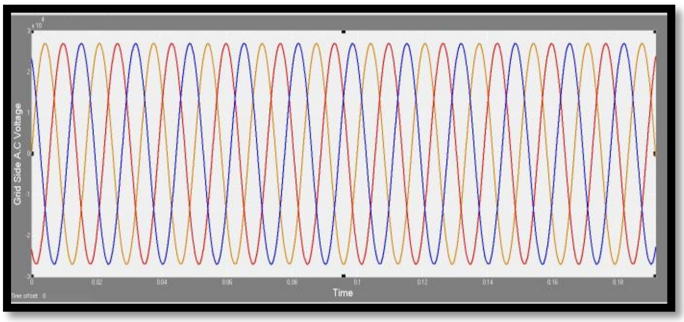

Fig 19- Grid side-controlled A.C output voltage by UPQC

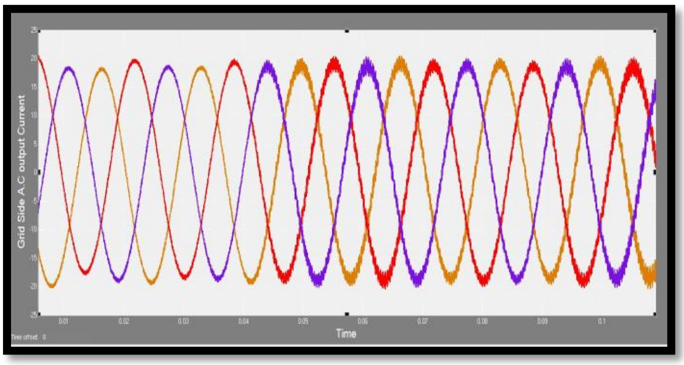

Fig 20- Grid side-controlled A.C output current by UPQC

PROPOSED SYSTEM WITH FLC CONTROL

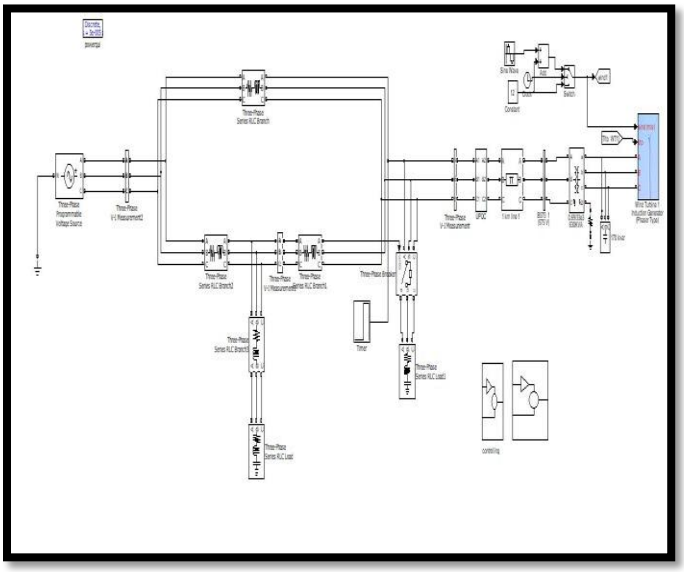
Fig 21-Proposed system with FLC

ISSN (Online): 2347 - 4718

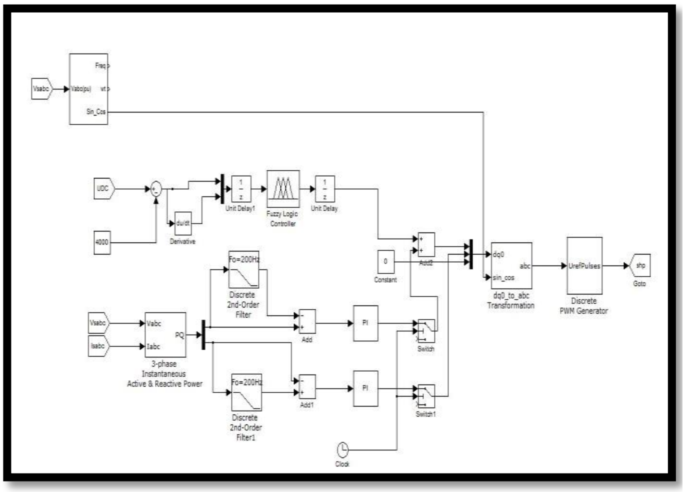

Fig 22-Fuzzy Logic Control system

SIMULATION RESULTS WITH UPQC USING FLC CONTROL

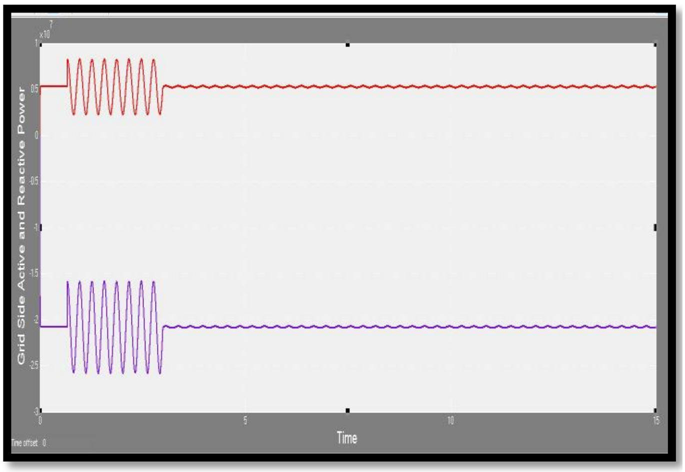

Fig.23- Grid Side Active and Reactive Power control using UPQC

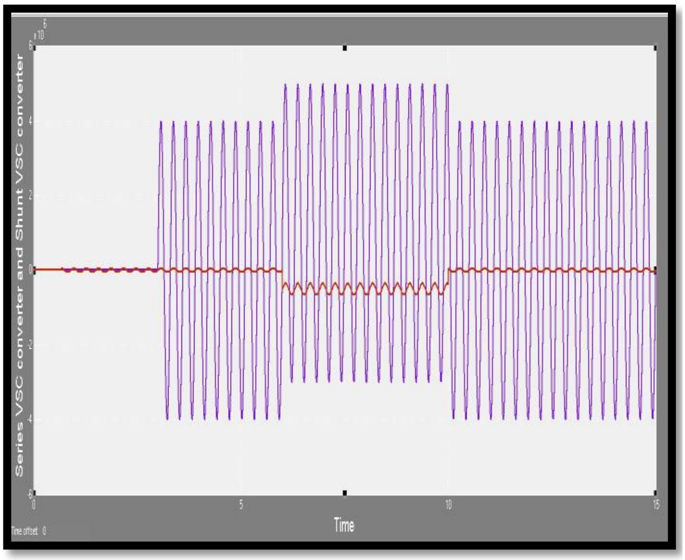

Fig.24- Series VSC controller and shunt VSC converter voltage variation

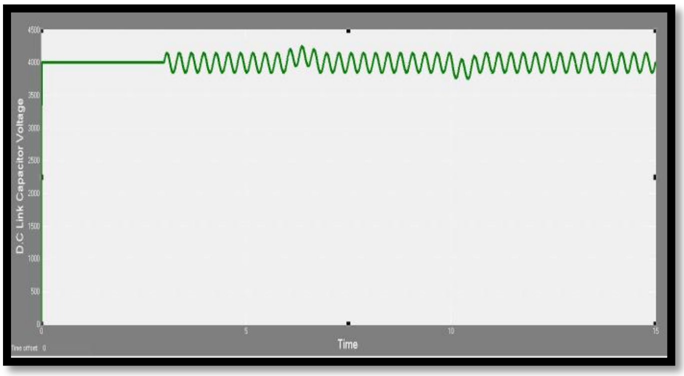

Fig.25- Common D.C link Capacitor voltage

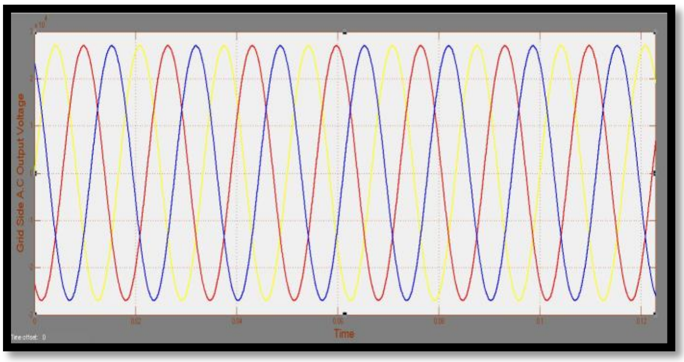

Fig 26-Grid Side output Voltage

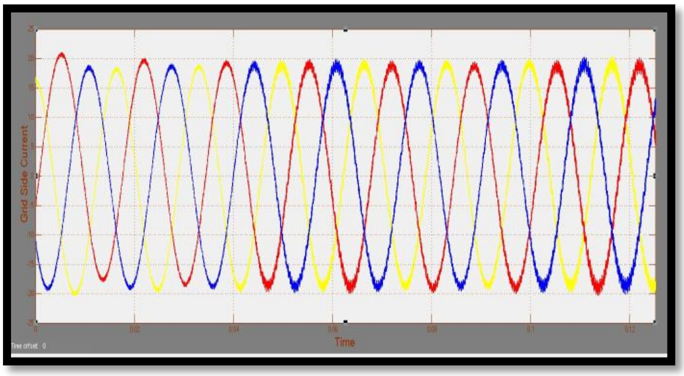

Fig 27-Grid Side Current

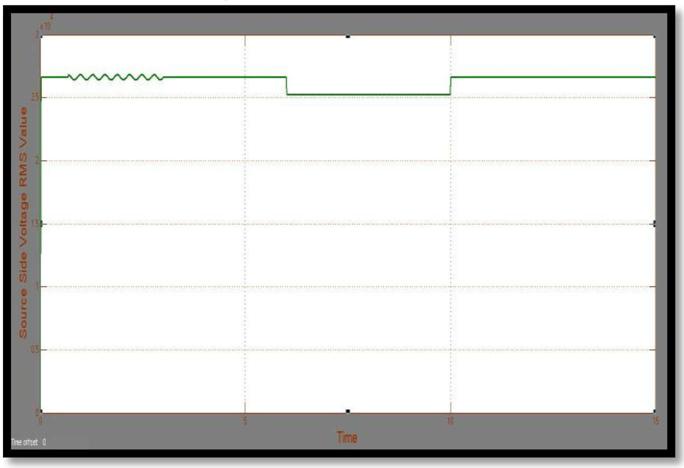

Fig 28-Source Side Voltage RMS Value

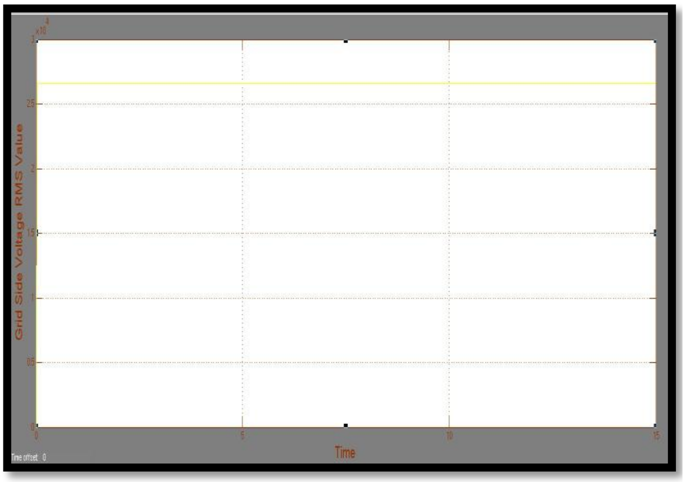

Fig 29-Grid Side Voltage RMS Value

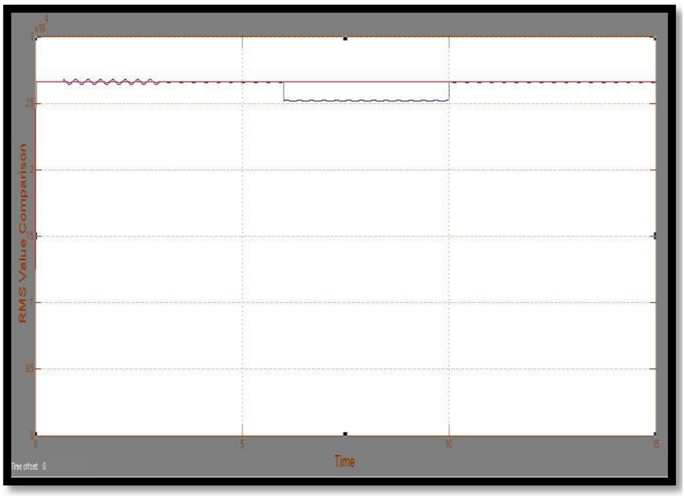

Fig 30-RMS Voltage comparison

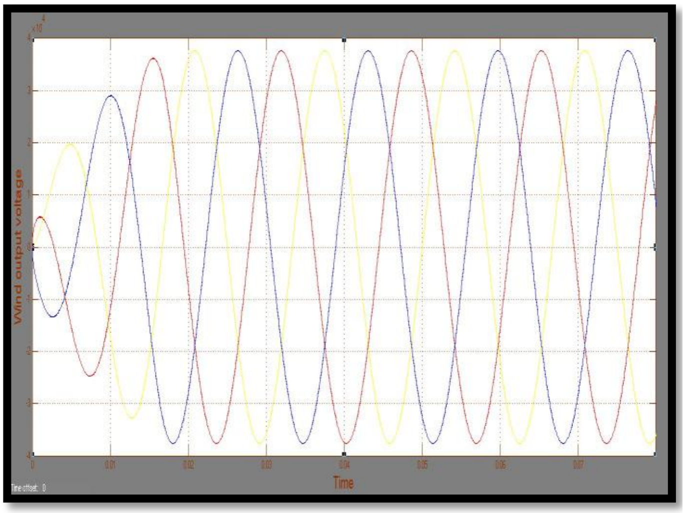

Fig 31-Wind Output A.C Voltage

V. CONCLUSION

Also, one major part of this thesis work is excess power of wind generation can store using high capacity batteries so that the power exchange with grid can be constant and the energy can be utilizing during pike load time. This gives power saving of base load plant and provide a non-polluting power time to time. Thus, the concept is another step in the field of non-polluting energy and reduction in carbon footprint. UPQC integration with DFIG provides power quality improvement with ESS system. The Matlab simulation shows the effectiveness of UPQC for PQ problems mitigation in DFIG wind power plant. The fuzzy controlled UPQC is implemented for PQ enhancement to diminish both voltage sag and current harmonics and the simulation results are also compared with conventional PI controller. From the simulation results, the PI controlled UPQC completely mitigates voltage sag but the load current harmonics obtained is not within the acceptable bounds. Thus the proposed Fuzzy controlled UPQC is successfully proven as efficient device through its outstanding performance for improving PQ in a grid connected wind power system.

REFERENCES

[1] R.Bhavani, Dr.N.Rathina Prabha and C.Kanmani, “Fuzzy Controlled UPQC for Power Quality Enhancement in a DFIG based Grid Connected Wind Power System”, 2015 International Conference on Circuit, Power and Computing Technologies [ICCPCT], 978-1-4799-7075-9/15/©2015 IEEE.

[2] G. Mallesham and CH. Siva Kumar, “Enhancement of Power Quality using UPQC for Hybrid PEMFC and DFIG Based Wind Energy System Connected to Weak Grid”, 2017 IEEE International Conference on Technological Advancements in Power and Energy (TAP Energy), 978-1-5386-4021-0/17/$31.00 ©2017IEEE.

[3] Mr. Chaudhary M.V., Prof. Tapre P.C., Prof. C Veeresh, “Enhancement of Power Quality Using UPQC in Hybrid Wind/diesel system with energy storage”, 978-1-5090-4620-1/16/ ©2016 IEEE.

[4] Gowtham N, Dr. Shobha Shankar, Dr. K Uma Rao, “Enhanced Firefly algorithm for PQ improvement of Wind Energy Conversion System with UPQC”, Proc. of the 2017 IEEE Region 10 Conference (TENCON), Malaysia, November 5-8, 2017, 978-1-5090-11346/17/©2017 IEEE.

[5] K.Naresh Kumar, Dr.S.Srinath, “Integration of UPQC with New Converter Transformer for Power Quality Improvement”, 2018 National Power Engineering Conference (NPEC), 978-1-5386-3803-3/18/ ©2018 IEEE.

[6] Senthil Vadivu U, B K Keshavan, “Power Quality Enhancement of UPQC Connected WECS using FFA with RNN”, 978-1-5386-3917-7/17/ ©2017 IEEE.

[7] Amita, Abhishek Kumar Sinha, “Power Quality Comparison of grid connected wind energy system with STATCOM and UPQC”, 2018 International Conference on Intelligent Circuits and Systems, 978-1-5386-6483-4/18/2018 IEEE.

[8] Vinod Khadkikar, “Enhancing Electric Power Quality Using UPQC: A Comprehensive Overview,” IEEE Transactions on Power

Electronics, vol. 27, no. 5, pp. 2284-2297, May 2012.

[9] Concept of Simultaneous Voltage Sag/Swell and Load Reactive Power Compensations Utilizing Series Inverter of UPQC,"IEEE Transactions on Power Electronics, vol. 26, no. 9, pp.2414-2425, September 2011.

[10] P. Karuppanan and Kamala Kanta Mahapatra, "PI and Fuzzy Logic Controllers for Shunt Active Power Filter," ISA Transactions, vol. 51, pp. 163-169, 2012.

[11] Andres E. Leon, Marcelo F. Farias, Pedro E. Battaiotto, Jorge A. Solsona and María Inés Valla, "Control Strategy of a DVR to Improve Stability in Wind Farms Using Squirrel-Cage Induction Generators," IEEE Transactions on Power Systems, vol. 26, no. 3, pp. 1609-1617, August 2011.

[12] Sharad W. Mohod and Mohan V. Aware, "A STATCOM Control Scheme for Grid Connected Wind Energy System for Power Quality Improvement," IEEE Systems Journal, vol. 4, no. 3, pp. 346-352, September 2010.

[13] Vinod Khadkikar and Ambrish Chandra, "UPQC-S: A Novel Concept of Simultaneous Voltage Sag/Swell and Load Reactive Power Compensations Utilizing Series Inverter of UPQC," IEEE Transactions on Power Electronics, vol. 26, no. 9, pp. 2414-2425, September 2011.

[14] G. Siva Kumar, Kalyan Kumar, and Mahesh K. Mishra, "Mitigation of Voltage Sags With Phase Jumps by UPQC with PSO-Based ANFIS," IEEE Transactions on Power Delivery, vol. 26, no. 9, pp. 2414-2425, September 2011.

[15] Vinod Khadkikar, "Enhancing Electric Power Quality Using UPQC: A Comprehensive Overview," IEEE Transactions on Power Electronics, vol. 27, no. 5, pp. 2284-2297, May 2012.

