Power Quality Improvement using STATCOM and UPQC with PI and Hysteresis Controllers

D. Ram Ganesh[1] | G. Chandra Sekhar[2] | K. Balu [3] | I. Prudhvi Kumar Raju[4]

[1,2,3]UG Students, Department of Electrical and Electronics Engineering,, Godavari Institute of Engineering and Technology (A), Rajahmundry, Andhra Pradesh, India.
[4]Assistant Professor, Department of Electrical and Electronics Engineering, Godavari Institute of Engineering and Technology (A), Rajamundary, Andhra Pradesh, India.

Abstract: Any power system consists of wide range of electrical, electronic and power electronic equipment in commercial and industrial applications. The quality of the power is affected by many factors like harmonic contamination due to non-linear loads, such as large thyristor power converters, rectifiers etc. Voltage and current flickering due to the arc furnaces, and sag/swell due to the switching loads also influence the sensitive loads to be fed from the system. Unified Power Quality Conditioner (UPQC) is a custom power device that consists of shunt and series converters connected back to back on the dc side and deals with load current and supply-voltage imperfections. The performance of UPQC mainly depends upon how accurately and quickly reference signals are derived. In the present paper UPQC model is designed which has a dc link for shunt and series compensation. The advantage is that the chance of malfunctioning of two converters is reduced. The control strategy for the two converters is designed in separate ways. Shunt compensation and series compensation of UPQC model are designed using PI and hysteresis controller respectively. Hysteresis current control will be designed to maintain the harmonic level below 5 percent.

KEYWORDS:HVDC Transmission, Simulation, Artificial Neural Network, Conventional controller.

DOI of the Article: https://doi.org/10.46501/GIETEE10

Available online at: https://ijmtst.com/icceeses2021.html

To Cite this Article: D. Ram Ganesh; G. Chandra Sekhar; K. Balu and I. Prudhvi Kumar Raju[4]. Power Quality Improvement using STATCOM and UPQC with PI and Hysteresis Controllers. *International Journal for Modern Trends in Science and Technology* 2021, *7*, pp. 65-70. https://doi.org/10.46501/GIETEE10

Article Info. Received: 20 May 2021; Accepted: 25 June 2021; Published: 30 June 2021

INTRODUCTION

Power quality is the set of limits of electrical properties that allows electrical system to function in proper manner without significant loss of performance. Like flexible ac transmission system, the term custom power use for distribution system. Just as facts improve the reliability and quality of power transmission system, the custom power enhances the quality and reliability of power that is delivered to customers. The main causes of a poor power quality are harmonic currents, poor power factor, supply voltage variations, etc.

In recent years the demand for the quality of electric power has been increased rapidly. Power quality problems have received a great attention nowadays because of their impacts on both utilities and customers. Voltage sag, swell, momentary interruption, under voltages, over voltages, noise and harmonics are the most common power quality disturbances. There are many custom power devices. The devices either connected in shunt or in series or a combination of both. The devices include D-STATCOM, DVR and UPQC etc.One of the most common power quality problems today is voltage dips. A voltage dip is a short time event during which a reduction in R.M.S voltage magnitude occurs. Despite ashort duration, a small deviation from the nominal voltage can result in serious disturbances. A voltage dip is caused by a fault in the utility system, a fault within the customer's facility or a large increase of the load current, like starting a motor or transformer energizing.

Unified power quality conditioner (UPQC) is one of the best custom power device used to compensate both source and load side problems [1]. It consists of shunt and series converters connected back to back to a common dc link. It can perform the functions of both DSTATCOM and DVR. In this paper a fuzzy logic controller is used to compensate voltage sag and it is compared with neural network based controller.

The addition of energy storage through an appropriate interface to the power custom device leads to a more flexible integrated controller. The ability of the UPQC-ESS to supply effectively active power allows expanding its compensating actions. Various types of advanced energy storage technologies can be incorporated into the dc bus of the UPQC, namely superconducting magnetic energy storage (SMES), ultra-capacitor energy storage (aka super-capacitor energy storage - UCES/SCES respectively) and flywheel energy storage (FES), among others. However, ultra-capacitors (UC) have distinct potential advantages for energy storage which make them almost unbeatable in many applications.

UPQC SYSTEM WITH CONTROL METHODS

UPQC mainly includes three parts: the series active power filters, shunt active power filters and energy storage capacitors.

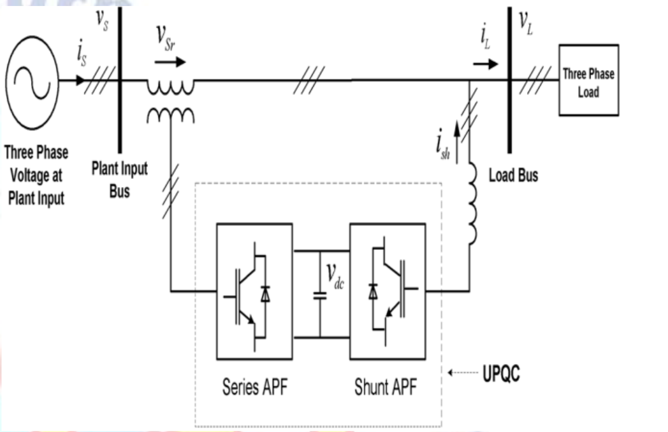

Fig 1. Topology of upqc

The series and shunt active power filter couples together through the DC-link energy storage capacitors. Series APF connected to the grid and load by coupling transformer is mainly used to adjust the load voltage amplitude and compensate the power supply voltage sag in the controlled voltage source mode. Shunt active filter connected to the load is used to compensate load currents.

PWM CONTROL OF ACTIVE POWER FILTER

The main aim of an active power filter (APF) is to generate compensating currents into the power system for canceling the current harmonics contained in the nonlinear load current. This will thus result in sinusoidal line currents and unity power factor in the input power system.Fig. 2 shows the configuration of a three-phase active power filter. The active power filter is connected in parallel with a nonlinear load. It consists of a power converter, a DC-link capacitor (C_2) and a filter inductor (L_2).

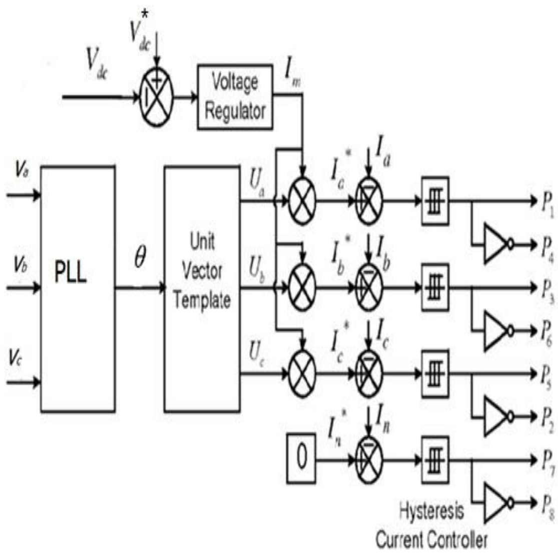

Fig 2. Shunt controller for UPQC

To eliminate current harmonic Components generated by nonlinear loads, the active power filter produces equal but opposite harmonic currents to the point of connection with the nonlinear load. This results in a reduction of the original distortion and correction of the power factor. The inductor L_2 is used to perform the voltage boost operation in combination with the DC-link capacitor C_2 and functions as a low pass filter for the line current of an active power filter.

SERIES CONTROL STRATEGY

The proposed algorithm is based on the estimation of reference supply currents. It is similar to the algorithm for the control of a shunt compensator like DSTATCOM for the terminal voltage regulation of linear and nonlinear loads [6]. The proposed control algorithm for the control of DVR is depicted in Fig 3.

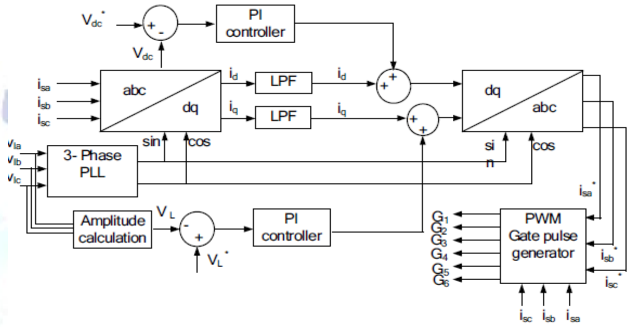

Fig 3. Control scheme of the DVR

DESIGN OF UPQC USING MATLAB SIMULATION

To verify the operating performance of the proposed UPQC, a 3-phase electrical system, PI controller with reference signal generation method is designed for UPQC and compared its performance with Hysteresis based controller is simulated using MATLAB software.

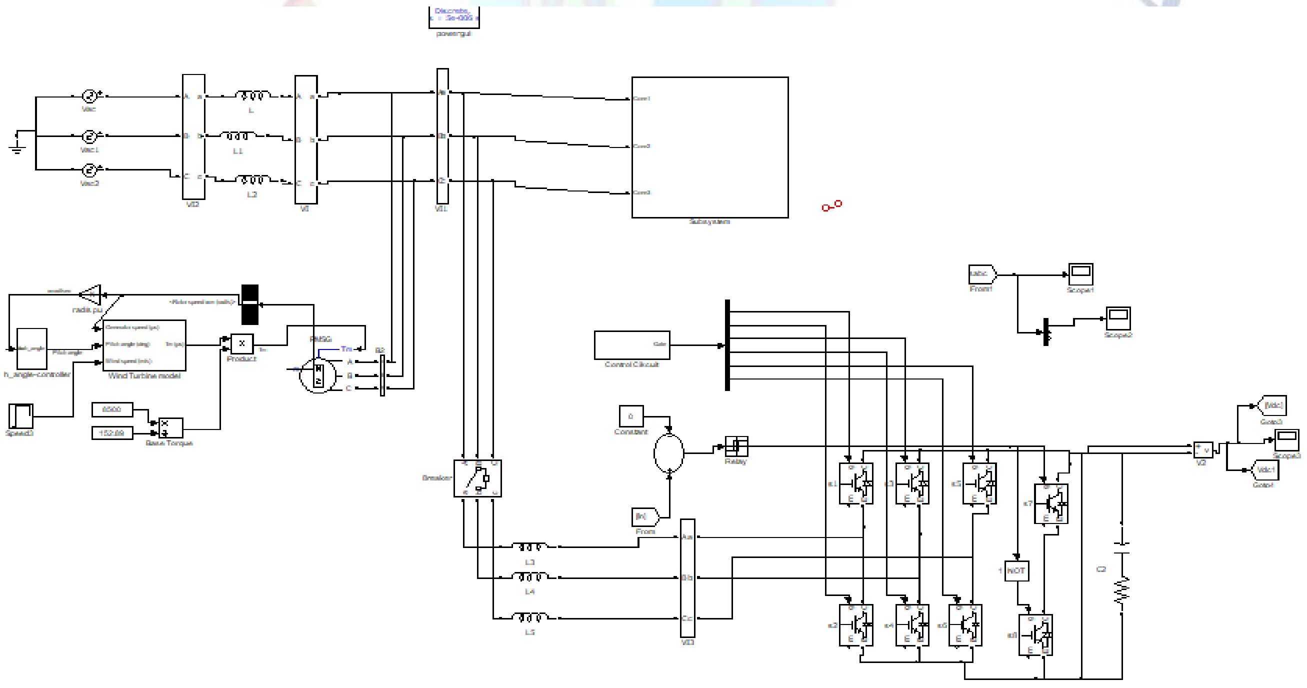

Fig.4. Simlink model of Statcom

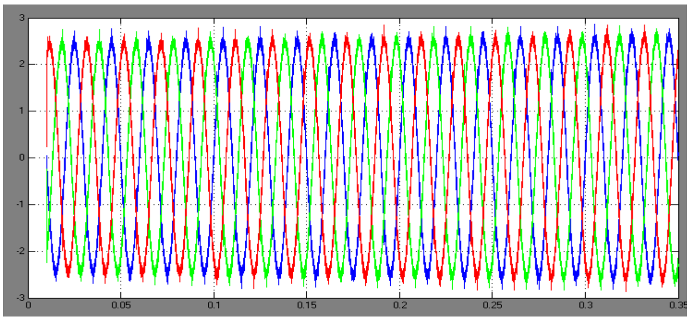

Fig.5 Source current using Statcom with PI controller

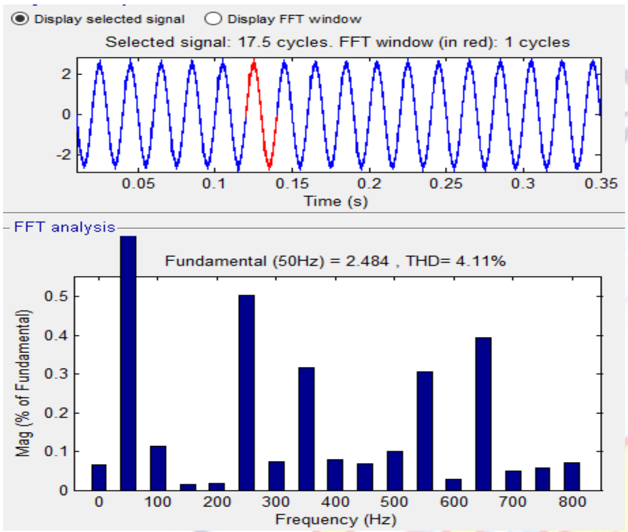

Fig.6 THD of Statcom with PI controller

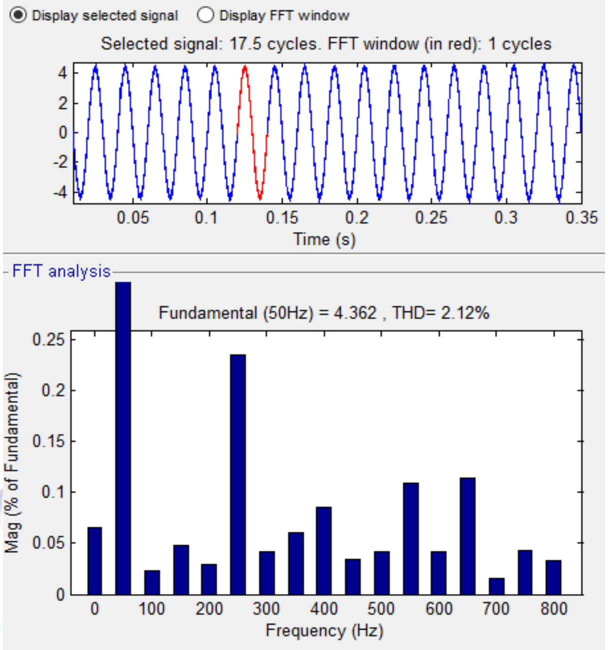

Fig.7 THD of Statcom with Hysteresis controlle

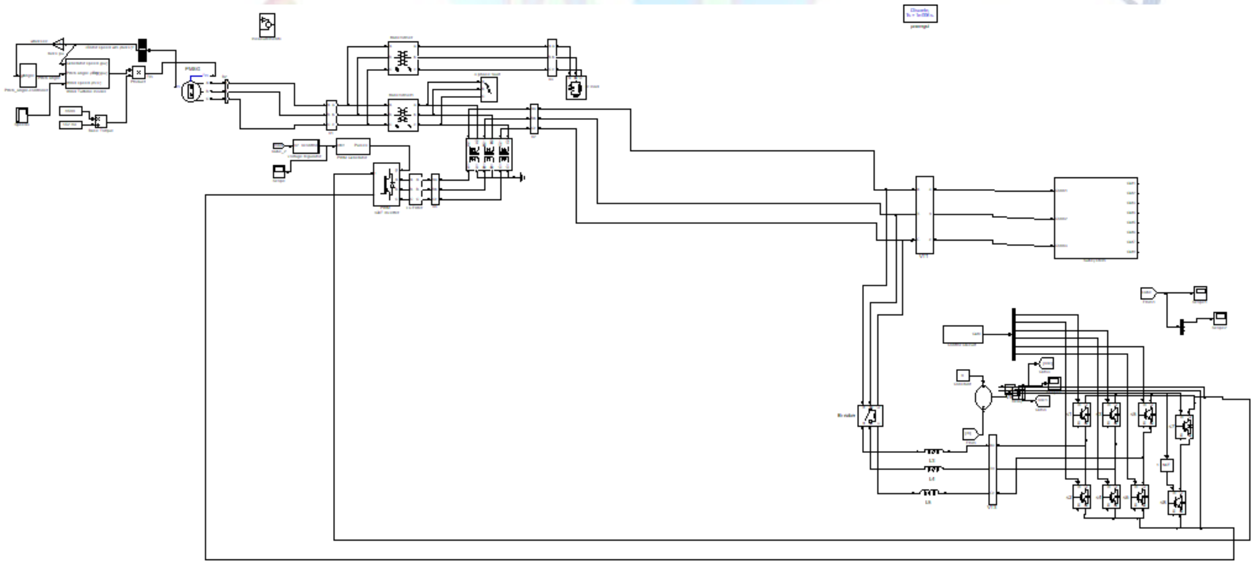

Fig.8. Simlink model of system with UPQC

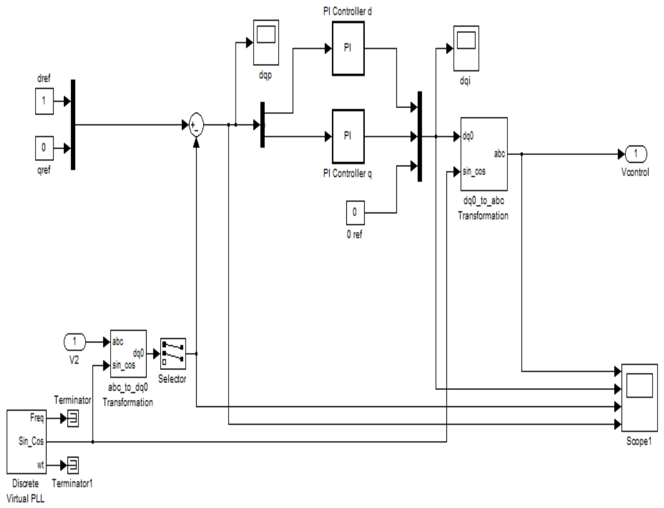

Fig 9. Series Active Power filter control

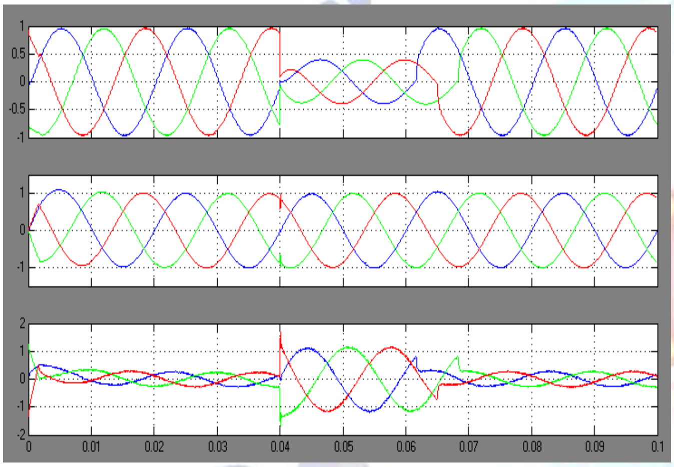

Fig 10. Three phase fault (Voltage) and compensation by using series active power filter

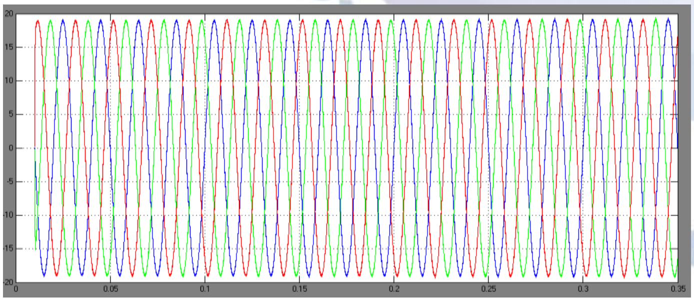

Fig 11. Source voltage using UPQC with PI Controller

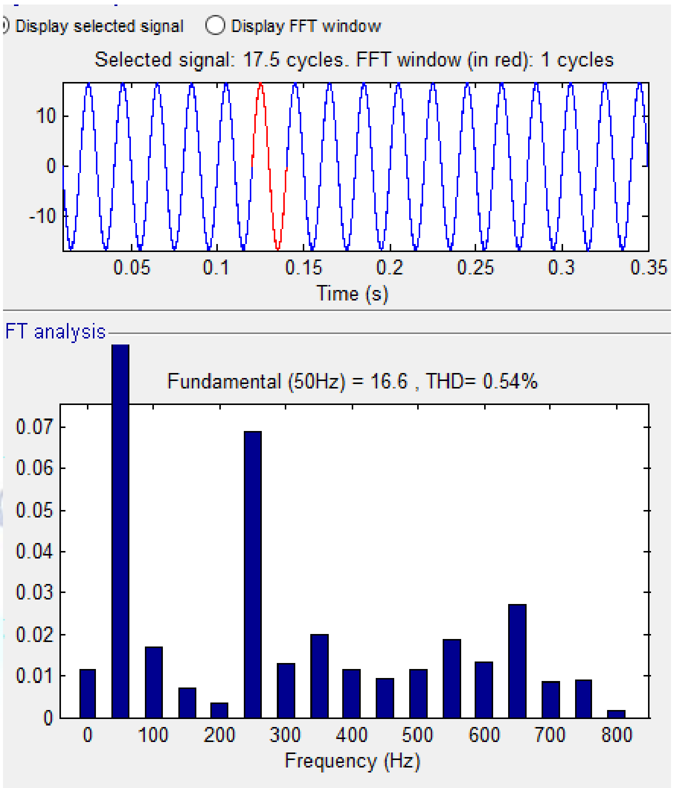

Fig .12. THD of UPQC with PI controller

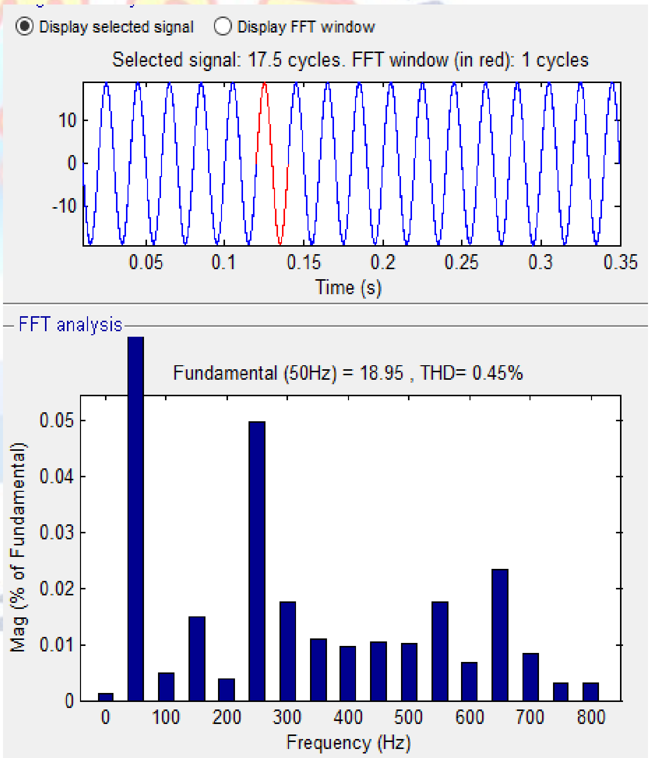

Fig .13. THD of UPQC with Hysteresis Controller

Table I: Total Harmonic Distortion (THD) Values

STATCOM with PI Controller	4.11	STATCOM with Hysteresis Controller	2.12
UPQC with PI Controller	0.54	UPQC with Hysteresis Controller	0.45

CONCLUSION

This paper is mainly devoted to the study of Power Quality problems and its compensation with Wind fed Unified power quality conditioner (UPQC). Results obtained from this study provide useful information regarding the behaviour of different controllers used for power quality improvement connected to distribution line. The controller mainly used for power quality improvement is PI and Hysteresis based controller. Hence as compared to the response obtained with Hysteresis based controller have great advantage of flexibility.PWM and hysteresis controllers used for harmonic reduction. When compared with PWM technique hysteresis control technique gives better results.

REFERENCES

[1] Vadirajacharya G. Kinhal, Promod Agarwal, and Hari Oam Gupta (2011), *Senior Member, IEEE* "Performance Investigation of Neural-Network- Based Unified Power-Quality Conditioner" ieee transactions on power delivery, vol.26.

[2] Ahmet Teke, Lütfü Saribulut, and Mehmet Tümay (2011) "A Novel Reference Signal Generation Method for Power- Quality Improvement of Unified Power-Quality Conditioner" ieee transactions on power delivery.

[3] Manoj, V. (2016). Sensorless Control of Induction Motor Based on Model Reference Adaptive System (MRAS). *International Journal For Research In Electronics & Electrical Engineering*, 2(5), 01-06

[4] L. H. Tey, P. L. So, and Y. C. Chu (2004), "Unified power quality conditioner for improving power quality using ANN with hysteresis control," in *Proc. Int. Conf. PowerSystem Technology*, pp. 1441–1446.

[5] Dinesh, L., Sesham, H., & Manoj, V. (2012, December). Simulation of D-Statcom with hysteresis current controller for harmonic reduction. In 2012 International Conference on Emerging Trends in Electrical Engineering and Energy Management (ICETEEEM) (pp. 104-108). IEEE.

[6] V. B. Venkateswaran and V. Manoj, "State estimation of power system containing FACTS Controller and PMU," 2015 IEEE 9th International Conference on Intelligent Systems and Control (ISCO), 2015, pp. 1-6, doi: 10.1109/ISCO.2015.7282281

[7] Ruiye Liu, Ning Xia, Xiaonan Wang" The Research on Fuzzy-PID Control in Unified Power Quality Conditioner".

[8] Timothy Ross J. (1995), "Fuzzy Logic with Engineering Applications", McGraw-Hillbook Company; University of Mexico.

[9] Manohar, K., Durga, B., Manoj, V., & Chaitanya, D. K. (2011). Design Of Fuzzy Logic Controller In DC Link To Reduce Switching Losses In VSC Using MATLAB-SIMULINK. Journal Of Research in Recent Trends.

[10] Manoj, V., Manohar, K., & Prasad, B. D. (2012). Reduction of switching losses in VSC using DC link fuzzy logic controller Innovative Systems Design and Engineering ISSN, 2222-1727.

[11] Dinesh, L., Harish, S., & Manoj, V. (2015). Simulation of UPQC-IG with adaptive neuro fuzzy controller (ANFIS) for power quality improvement. Int J Electr Eng, 10, 249-268

[12] HUANG Min, ZHA Xiao-ming, CHEN Yun-ping (2002), The controller of fuzzy changing structure of parallel power quality conditioner[J]. Power System Technology,26(7):11-14.

[13] J. Schindall, "The Charge of the Ultra-Capacitors," IEEE Spectrum, vol.44, no. 11, pp. 42-46, Nov. 2007.

[14] Zouidi, F. Fnaiech, and K. AL-Haddad (2006), "Neural network controlled three-phase three-wire shunt active power filter," in Proc. IEEE ISIE, Montreal, QC, Canada, Jul. 9–12,pp. 5–10.