International Research Journal of Engineering and Technology (IRJET) **e-ISSN: 2395-0056**
Volume: 05 Issue: 05 | May-2018 **www.irjet.net** **p-ISSN: 2395-0072**

A Novel ANN Dual Control Strategy for Power Quality Improvement Using UPQC

Mrs. Rosemin Raj M[1], Mrs. Jisi. N.K[2]

[1]*M Tech Student ,Dept. of EEE Engineering, Thejus Engineering College, Kerala ,India*
[2]*Assistant Professor, Dept. of EEE Engineering, Thejus Engineering College, Kerala, India*

***

Abstract -*This paper presents the study and analysis of a versatile unified power quality conditioner (UPQC).In a power system network there are many problems related to power quality. UPQC is used for power quality improvement. It is a combination of shunt active power filter and series active power filter. In this UPQC employs a dual control strategy, such that the controlled quantities are always sinusoidal. Series active power filter is used to mitigate for voltage distortion and unbalance which is present in supply side and make the voltage at load side perfectly balanced. Shunt active power filter issued to compensate for load current harmonics and make the source current free from harmonics and distortions. Control scheme is based on dq0 transformation.*

Key Words: **Active power filter , dual control strategy, UPQC, DC-link**

1. INTRODUCTION

In today's world there is great importance of electrical energy as it is the most famous from of energy. Without supply of electricity life cannot be imagined. At the same time the quality and continuousness of the electric power supplied is also very important for the efficient functioning of the end user equipment. Many of the commercial and industrial loads require high quality undisturbed and constant power. Thus maintaining the qualitative power is topmost important in today's world. Due to power electronics devices there is serious effect on quality and continuousness of electric supply. Because of power electronics devices there is uninterrupted power supply, flicker, harmonics, voltage fluctuations e.t.c. There is also PQ problems such as voltage rise/dip due to network faults, lightning, switching of capacitor banks. With the excessive uses of non-linear load (computer, lasers, printers, rectifiers) there is reactive power disturbances and harmonics in power distribution system. It is very essential to overcome this type of problems as its effect may increase in future and cause adverse effect. Traditionally passive filters were used for reactive power disturbances and harmonics generation but there is many problems with them like they are large in size, resonance problem, effect of source impedance on performance. Active Power Filters are used for power quality enhancement. Active power filters can be classified according to system configuration. Active power filters are of two types series and shunt. Combining both series APF & shunt APF we get a device known as UPQC. UPQC eliminates the voltage and current based distortions together. A Shunt APF eliminates all kind of current problems like current harmonic compensation, reactive power compensation, power factor enhancement. A Series APF compensates voltage dip/rise so that voltage at load side is perfectly regulated. The Shunt APF is connected in parallel with transmission line and series APF is connected in series with transmission line. UPQC is formed by combining both series APF and shunt APF connected back to back on DC side. In this controlling techniques used is hysteresis band controller using "p-q theory" for shunt APF and hysteresis band controller using Park's transformation or dq0 transformation for series APF. UPQC is made by combining both shunt APF and series APF. UPQC is used to eliminate all problems due to current harmonics and voltage unbalances & distortions and improve power quality of a system. UPQC is a very versatile device as at same time it mitigates the problem both due to current and voltage harmonics. In this thesis power quality of system was improved by using UPQC.

2. UPQC TPOPLOGY

The UPQC topology employed to implement the dual compensation strategy presented in this paper . It is comprised of both series and shunt active power filter sharing the same DC-link.

Series APF:- It is connected in series to the transmission line with the transformer. It is used to compensate or mitigate the problems which come due to voltage distortions and voltage unbalances. The series APF injects a compensating voltage so that load voltage will be perfectly balanced and regulated. Controlling of series inverter is done by synchronous reference frame theory.

Shunt APF: - In a transmission line shunt APF is generally connected in parallel. Shunt APF is used to compensate for distortions & harmonics which are produced due to current. Due to non- linear load there is harmonics in load current, so to keep source current completely sinusoidal and distortion free we uses Shunt APF. Shunt APF injects compensating current so that the source current is completely sinusoidal and free from distortions. Controlling of Shunt APF is done by hysteresis band PWM techniques and synchronous reference frame theory.

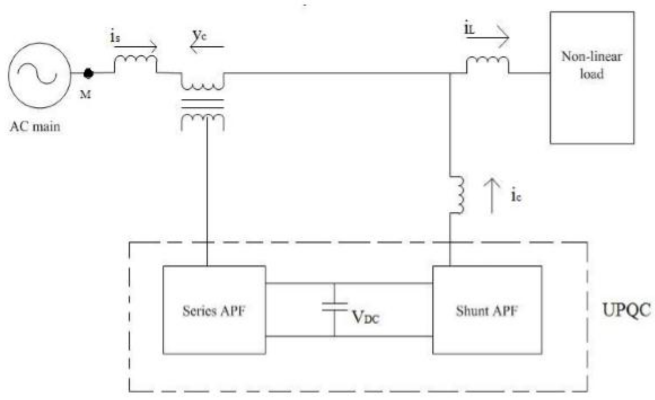


Fig -1: Circuit diagram of UPQC

Series Transformer:- The necessary voltage which is generated by series APF so that the voltage at load side is perfectly balanced and regulated i.e. Sinusoidal is injected into the transmission line with the help of these transformers. The series transformer turns ratio should be suitable so that injected voltage is suitable such that it injects a compensating voltage which will completely make the load side voltage balanced and also it reduces the current flowing through series inverter.

Low Pass Filter:- Low pass filter is used at the output of series inverter so that the high frequency voltage components are removed which is produced due to switching of Voltage source inverter

High pass filter:- High pass filter is used at output of shunt inverter so that the ripples which are produced due to currents switching are absorbed.

DC link capacitor:- Series APF and shunt APF are connected back to back through a DC capacitor. DC capacitor is provides a DC voltage for working of series and shunt active power filters . During steady state real power supplied by source should be equal to the sum real power demand of load & a small amount of power which compensates for active filter. DC capacitor voltage should be equal to reference value but due to disturbance in real power balance between source and load due to change in load conditions the DC capacitor value is changed from reference value.

2.1 Dual Compensation Principle

The strategies used to generate the sinusoidal reference quantities used to control the series and the parallel converters .Both the current and voltage control references are controlled to be in phase with the utility voltages. In Dual compensating strategy ,the parallel PWM converter is controlled to isolate the harmonic currents generated by the non-linear loads. The series PWM converter also makes the output voltages sinusoidal, balanced, regulated and in phase with the utility voltages.

2.2 SRF Theory(dq theory)

The control scheme for series and shunt active filters are provided by using SRF controller. Although there are many control approaches available for the generation of reference signals. SRF controller is more preferable due to its robustness, simplicity and easy to design . The reference signal using SRF is extracted by transforming the three phase components into two phase components and again by transforming into three phase components after analysis using Park's transformation. PLL plays an important role in the design of SRF. PLL is used to achieve synchronization with distorted voltage and current . Three-phase distorted voltages are given to PLL which generates phase angle to maintain synchronization with sinusoidal voltage and current. In UPQC applications, the fundamental positive sequence component of the signals must be separated to compensate the load voltage and load current harmonics. In this process, the PLL has better performance under unbalanced and distorted system conditions. Thus the SRF control strategy produces an effective response by extracting the load current and load voltage distortion and also balances the unbalance system

3. Power Flow Analysis of Upqc

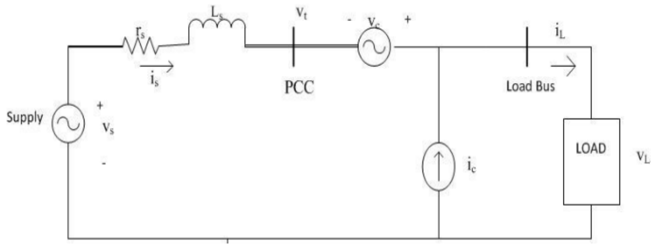


Fig -2: Circuit diagram of UPQC

Here v_s = source voltage

i_s = source current

v_t = terminal voltage at PCC

v_L = load voltage

i_L = load current

i_c = compensating current of shunt APF

v_c = injected voltage by series APF

UPQC is used to eliminate harmonics present in current and distortions of voltage. In UPQC series APF is used to compensate for voltage distortions and make voltage at load side completely balanced and sinusoidal. Series APF injects a voltage which is difference of source voltage and perfectly balanced load voltage. Shunt APF is used to eliminate harmonics present in load current so that source current is completely sinusoidal and also used for compensation of reactive power. Shunt APF is also used to maintain value of DC link capacitor constant.

1) CASE I: In this case series APF is used to supply real power to load. This is the voltage dip (sag) condition here is will be higher than normal current. In this required power is taken from source at increased current so that power will be balanced in the network and DC capacitor value should be at desired level. Here series injected power will be positive.

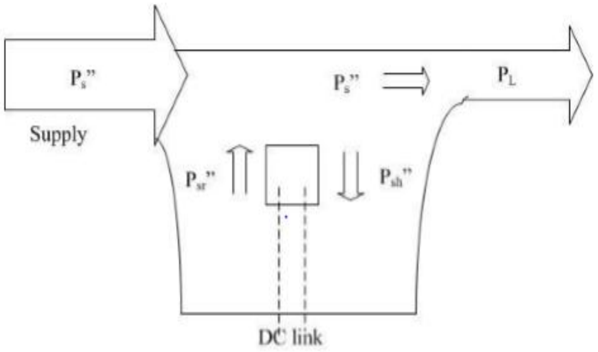


Fig -3: Real power flow during voltage sag condition

Here

P_s” = power supplied form the source to load during voltage sag condition.
P_{sr}”=seriesAPF injected power
P_{sh}” = shunt APF absorbed power during voltage dip condition
P_{sr}”=Psh’

From source to Shunt APF the real power flows, first real power flow from source to shunt APF and then from shunt APF to series APF through DC link capacitor and from Series APF to load. So load will get desired power during voltage sag condition. In this case the real power absorbed by shunt APF from source is equal to real power supplied by series APF to load.

2)CASE II: Here Series APF absorbs more power from source here P_{sr}” is negative. This happens during voltage rise (swell) condition. Here i_s will be lesser than normal current. As v_s is increased DC link capacitor voltage increases. Shunt APF lessen the current from supply so that the DC link voltage remains constant. UPQC gives extra amount of power to system.

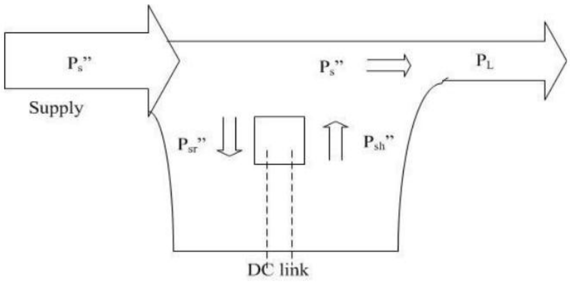


Fig -4: Real power flow during voltage swell condition

Here

P_s” = power supplied form the source to load during voltage rise condition.
P_{sr}” = series APF injected power;
P_s”- P_{sr}”=required voltage by load during normal condition
P_{sh}” = shunt APF delivered power during voltage rise condition
P_{sr}” = P_{sh}”

2)CASE III: In this case no real power flow through UPQC and it is normal condition of operation. Given in fig. 3.5

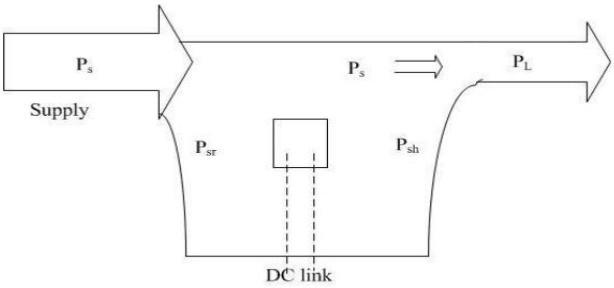


Fig -5: Real power flow in normal condition

4. Conventional control

In order to enhance the performance of the distribution system the UPQC model is proposed. UPQC is a combination of shunt and series active filter where shunt active filter compensates the current harmonics and series active filter compensates the voltage unbalance. The block diagram of conventional PI controller based UPQC is shown in Fig 6. The block diagram consists of two back to back connected series and shunt inverters, the PI controller to maintain the regulated voltage across the dc-link capacitor, SRF controller to extract the reference voltage and current signals to compensate the distortion.

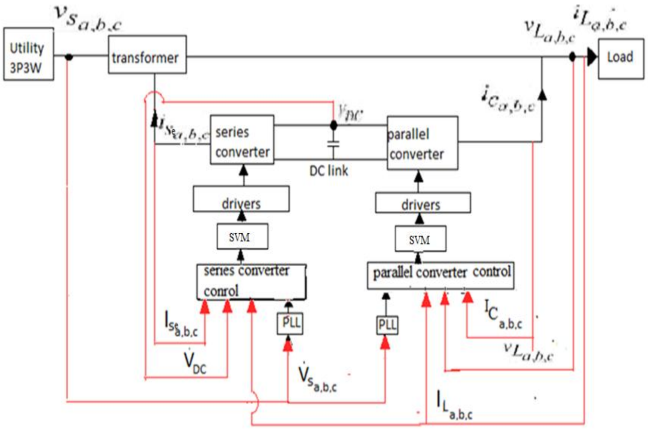


Fig -6: Block diagram of UPQC

PLL which is used to synchronize the phase angle with SRF to generate the switching signals to the series and shunt inverters respectively. For controlling series active filter V_{Labc}

(three phase load voltage) and V_{cabc} (three phase compensating voltage) are sensed. For controlling parallel active filter I_{Labc}, V_{DC}(DC link voltage) and I_{cabc} (compensating current) are sensed. V_{sabc} is used for getting phase angle for synchronization. Compensating current reference is generated for parallel active filter control and compensating voltage reference is generated for series active power filter control. Reference signals are converted into switching pulses using space vector modulation technique.

4.1 Control of series Active Power Filter

The inputs that are coming to series converter are i_{labc},v_{dc},v_{sabc} & i_{sabc}. From this V_{sabc} is transformed to v_α and v_β these are given as inputs to STF. By the help of PLL, phase angle will be generated. By using this phase angle I_{Labc} will get transformed into dqo components. From this extract d and q component. By comparing V_{DCref} and V_{DC} error is generated and Idc is obtained using PI controller. When we add the I_{DC} and I_{Ld} we get I_{sdref}. Then I_{sabc} is transformed to dqo. Then we will get I_{sd} and Isq. By comparing I_{sdref} and I_{sd} and giving to PI controller. I_{sqref} will set to zero. By comparing Isqref and I_{sq} which is given to PI controller. These two PI controller output is given to dqo/αβ transformation. By using Svm ,pulse will be generated and given to series converter.

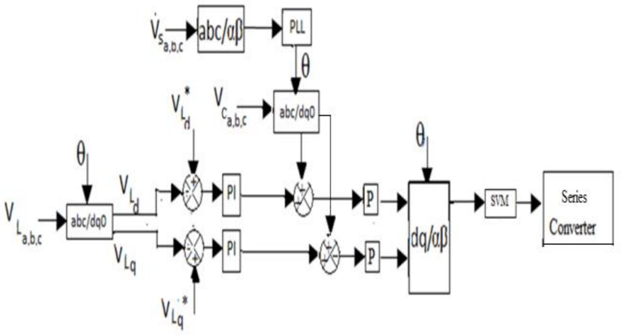


Fig -7: series converter control

4.2 ontrol of Shunt Active Power Filter

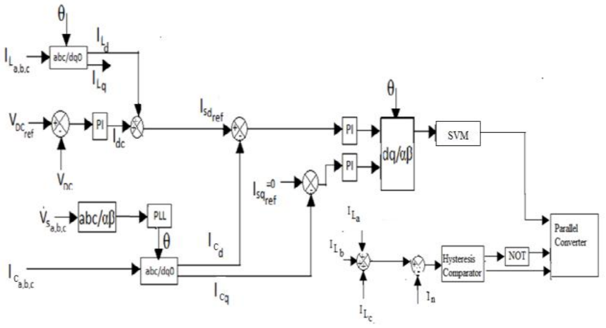


Fig -8: parallel converter control

I_{Labc} and I_{Cabc} is transformed in to I_{Ld},I_{Lq},I_{Cd} and I_{Cq} repectively. V_{dc} is compared with V_{dc} ref and fed in to DC voltage DC voltage controller .and I_{dref} is obtainted. Similarly I_{qref} is selected as zero. Then I_{dref} and I_{qref} are compared with Id and I_q actual quantities and fed in PI controller to obtain current reference for controlling shunt APF. For nutral current compensating I_{NL} is compared with zero and fed into histerisis controller. After that all reference quantities are fed in to SVM controller to generating switching pulse.

5. Proposed control

An artificial neuron network (ANN) is a computational model based on the structure and functions of biological neural networks. Information that flows through the network affects the structure of the ANN because a neural network changes - or learns, in a sense - based on that input and output. ANNs are considered nonlinear statistical data modeling tools where the complex relationships between inputs and outputs are modeled or patterns are found. ANN is also known as a neural network. An ANN has several advantages but one of the most recognized of these is the fact that it can actually learn from observing data sets. In this way, ANN is used as a random function approximation tool. These types of tools help estimate the most cost-effective and ideal methods for arriving at solutions while defining computing functions or distributions. ANN takes data samples rather than entire data sets to arrive at solutions, which saves both time and money. ANNs are considered fairly simple mathematical models to enhance existing data analysis technologies. ANNs have three layers that are interconnected. The first layer consists of input neurons. Those neurons send data on to the second layer, which in turn sends the output neurons to the third layer. Training an artificial neural network involves choosing from allowed models for which there are several associated algorithms. Artificial Neural Networks are famous learning models for their ability to cope with the demands of a changing environment. This network works with supervised learning where data set is presented to train the network before simulation is run to get output results. This ANN controller has two units . Neural networks in computer world work on the human brain's mechanism of problem solving strategies. In a human brain, several linkages (connections) are provided through networks of axons and synapses to the computing elements called neurons. They communicate to each other in chemical environment where electrical impulses are generated among them to pass information.

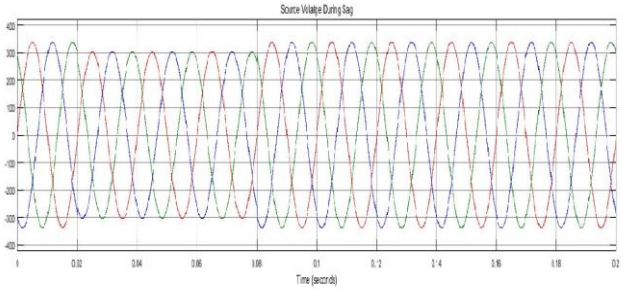
6. Results

The simulation model of the Distribution system is built by MATLAB simulation software to verify the effectiveness of the proposed controller. Table 5.1 shows the system parameters. In the simulation, two cases are taken into account:

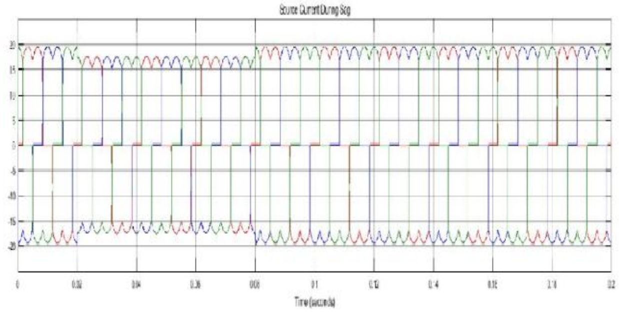
1. Case I: Without UPQC
2. Case II: With UPQC using PI controller

3. Case III: With UPQC using ANN

Before compensation the current and voltage at load side is shown in Fig 9

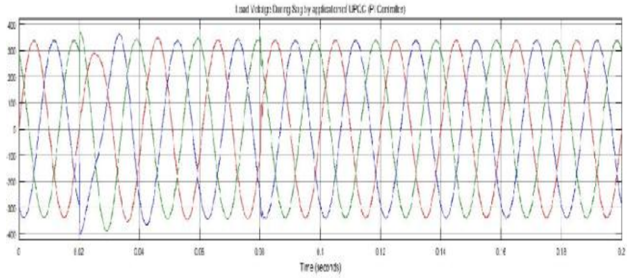


(a) source voltage

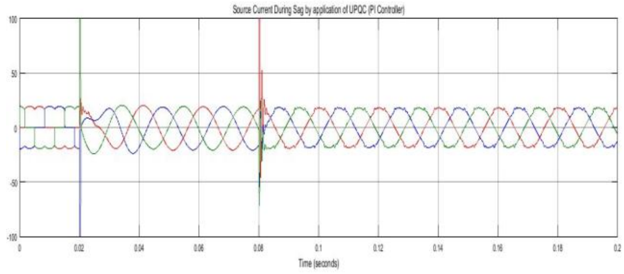


(b) source current

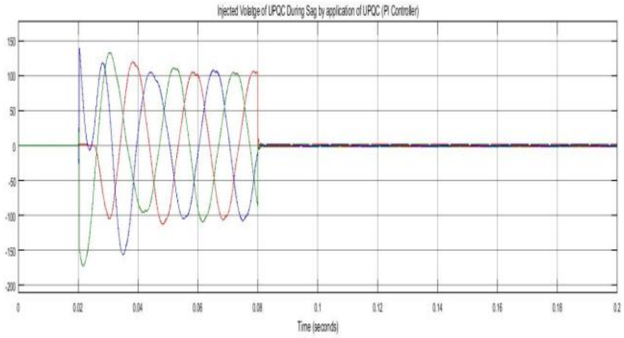
Fig -9: case I (Harmonics and sag mitigation without UPQC)



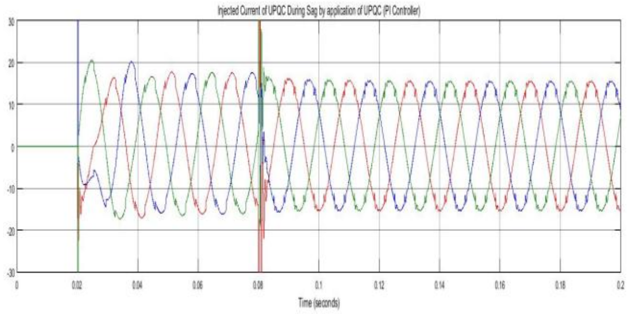
(a)Load voltage



(b)source current

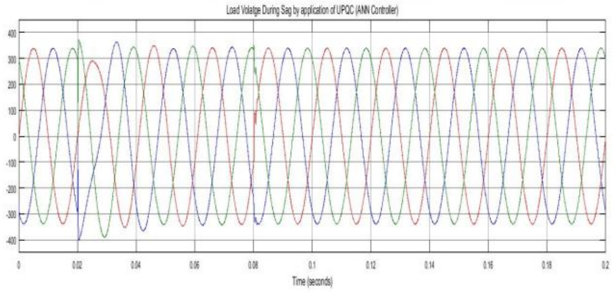


(c) Injected voltage

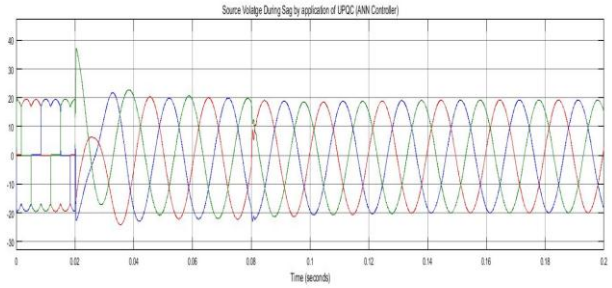


(d) Injected current

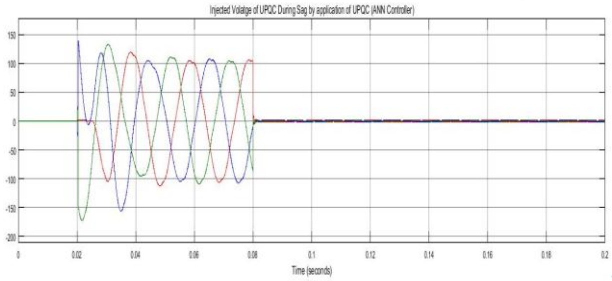
Fig -10 Case II(Harmonics and sag mitigation using PI Controller)



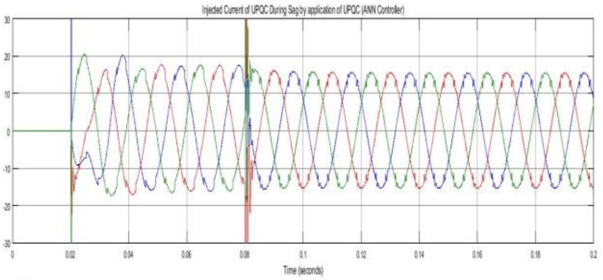
(a)Load voltage



(b)source current

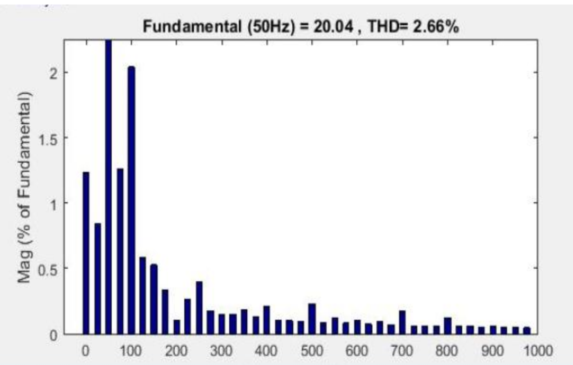


(c)Injected voltage

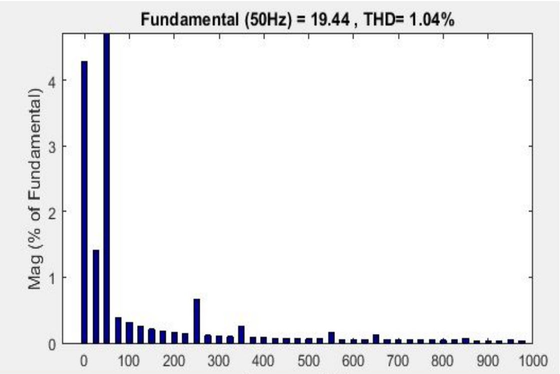


(d) Injected current

Fig -11: Case III(Harmonics and sag mitigation using ANN Controller)

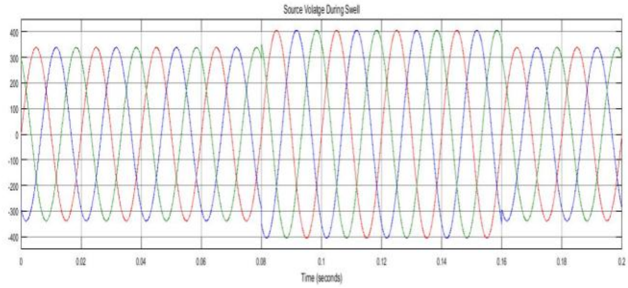


Case II

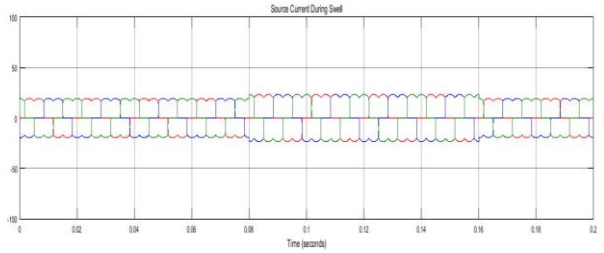


Case III

Fig -12:FFT Analysis harmonics and sag mitigation

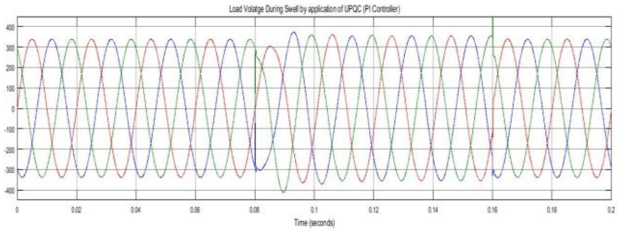


(a)Load voltage

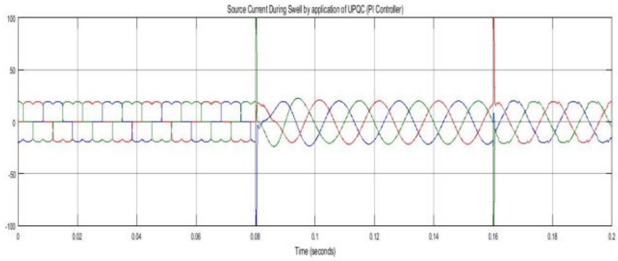


(b)source current Case I

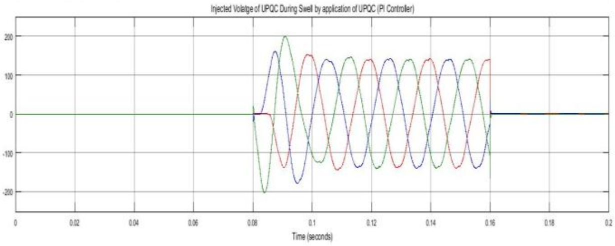
Fig -13: (Harmonics and swell mitigation without UPQC)



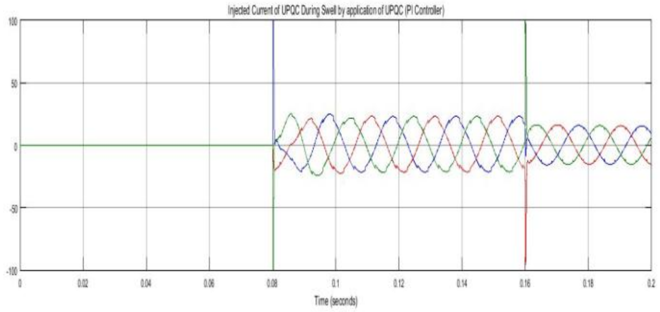
(a)Load voltage



(b)source current



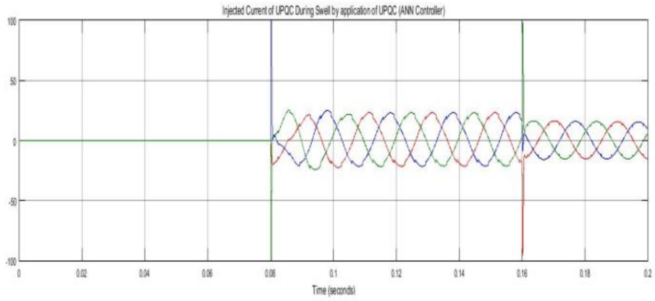
(c) Injected voltage



(d) Injected current

Case II

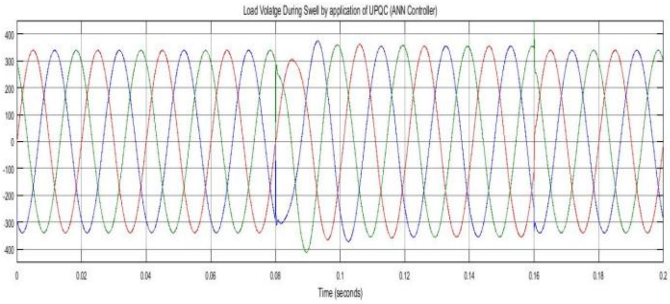
Fig -14: Harmonics and swell mitigation using PI controller



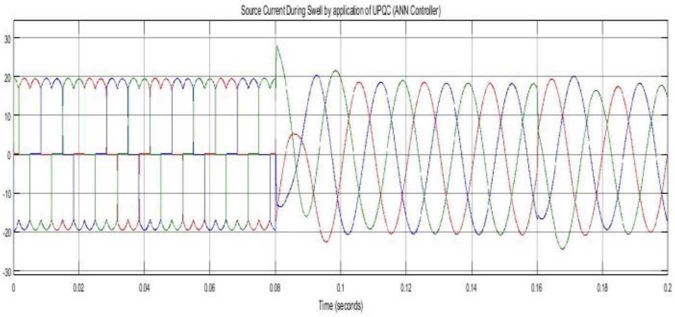
(d) Injected current

Case III

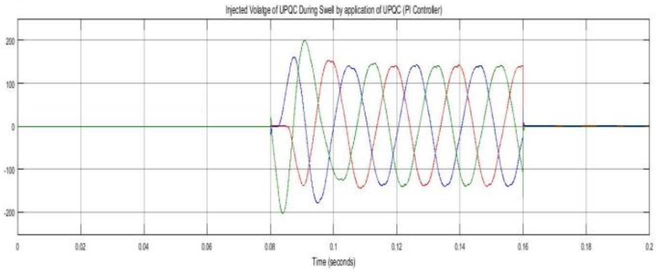
Fig -15: Harmonics and swell mitigation using ANN



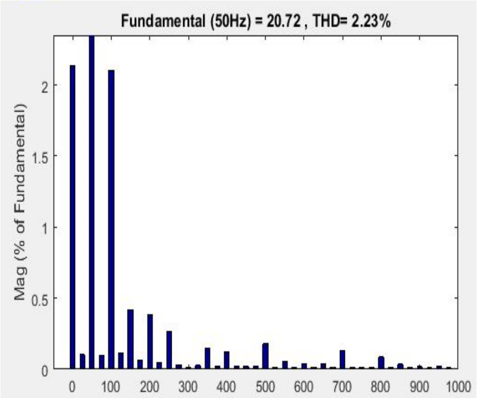
(a)Load voltage



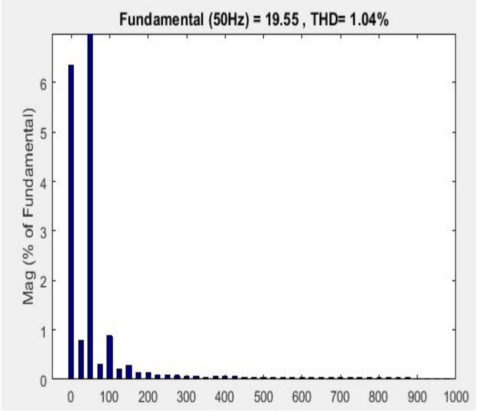
(b)source current



(c) Injected voltage



Case II



Case III

Fig -16: FFT Analysis harmonics and swell mitigation

3. CONCLUSION

Versatile application based on UPQC, which can be used in 3P3W as well as 3P4W distribution systems. By using a dual control compensating strategy, the controlled voltage and current quantities are always sinusoidal. Possible to reduce the complexity of the algorithms used to calculate the compensation references. SRF-based controllers are employed, then control references become continuous, reducing the steady-state errors.

REFERENCES

[1] H. Akagi, Y. Kanazawa, and A. Nabae, "Instantaneous reactive power compensators comprising switching devices without energy storage components," IEEE Trans. Ind. Appl., vol. 20, no. 3, pp. 625–630, 1984.

[2] F. Kamran, and T. Habetler, "A novel on-line UPS with universal filtering capabilities," IEEE Trans. Power Electron., vol. 13, no. 3, pp. 410-418, May 1998

[3] M. I. M. Monteiro, E. R. Cadaval, and F. B. González, "Comparison of control strategies for shunt active power filters in three-phase four-wire system," IEEE Trans. Power Electron., vol. 22, no. 1, pp. 229-236, Jan. 2007

[4] V. Khadkikar, and A. Chandra, "A novel structure for three-phase fourwire distribution system utilizing unified power quality conditioner (UPQC)," IEEE Trans. Ind. Appl., vol. 45, no. 5, pp. 1897-1902, Sept./Oct. 2009.

[5] R. J. M. Santos,. J. C. Cunha, and M. Mezaroba, "A simplified control technique for a dual unified power quality conditioner," IEEE Trans. Ind. Electron., vol. 61, no. 11, pp. 5851-5860, Nov. 2014.

[6] B.W. França, L.F. Silva, M. A Aredes, and M., Aredes, "An improved iUPQC controller to provide additional grid-voltage regulation as a STATCOM," IEEE Trans. Ind. Electron., , vol. 62, no. 3, pp. 13451352, Mar. 2015.

[7] M. Ucar, S. Ozdemir, and E. Ozdemir, "A four-leg unified series– parallel active filter system for periodic and non-periodic disturbance

[8] compensation," Electric Power Systems Research, vol. 81, pp. 11321143, 2011.

[9] M. Kesler, and E. Ozdemir, "Synchronous-reference-frame-based control method for UPQC under unbalanced and distorted load conditions," IEEE Trans. Ind. Electron., vol. 58, no. 9, pp. 3967-3975, Sept. 2011.

[10] J. A. Muñoz, J. R. Espinoza, C. R. Baier, L. A Morán, E. E. Espinosa, P. E. Melín, and D. G Sbárbaro, "Design of a discrete-time linear control strategy for a multicell UPQC," IEEE Trans. Ind. Electron., vol. 59, no. 10, pp. 3797-3807, Oct. 2012.

[11] S. B. Karanki, N. Geddada, M. K. Mishra, and B. K. Kumar, "A modified three-phase four-wire UPQC topology with reduced DC-link voltage rating," IEEE Trans. Ind. Electron., vol. 60, no. 9, pp. 35553566, Sept. 2013.

[12] M. Ucar, and S. Ozdemir, "3-phase 4-leg unified series–parallel active filter system with ultracapacitor energy storage for unbalanced voltage sag mitigation," Electric Power Systems Research, vol. 49, pp. 149-159, 2013.

[13] A. Teke, M. Meral, M. Cuma, M., Tümay, and C. A. Kamil, "Open unified power quality conditioner with control based on enhanced phase locked loop," IET Generation, Transmission Distribution, vol. 7, no. 3, pp. 254–264, Mar. 2013.

[14] W. R. N. Santos, E. R. C. da Silva, C. B. Jacobina, E. M. Fernandes, A. C. Oliveira, R. R. Matias, D. F. G. Filho, and O. M. Almeida, "The transformerless single-phase universal active power filter for harmonic and reactive power compensation," IEEE Trans. Power Electron., vol. 29, no. 7, pp. 3563-3572, Jul. 2014.

[15] M. Brenna, R. Faranda, and E. Tironi, "A new proposal for power quality and custom power improvement: Open UPQC," IEEE Trans. Power Delivery, vol. 24, no.4, pp. 2107-2116, Oct. 2009.

[16] B. B. Ambati, and V. Khadkikar, "Optimal sizing of UPQC considering VA loading and maximum utilization of power-electronic converters," IEEE Trans. Power Delivery, vol. 29, no. 3, pp. 1490-1498, Jun. 2014.