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EXTENSION OF FOURIER TRANSFORM FOR VERY FAST REFERENCE GENERATION OF UPQC

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Abstract- The Unified Power Quality Conditioner (UPQC) has composed of two back to back connected series and parallel Active Power Filters. It can be used in a power distribution network by unbalanced and distorted voltages and currents to provide balanced and sinusoidal source currents and load voltages. This paper proposes a fast reference signal generation method for Unified Power Quality Conditioner. Main principle of the proposed control system is based on the Fourier transform theory. Fourier transform can be used in unbalanced and harmonic conditions for the extraction of reference signals. But, its settling down time is one cycle which results in week capability in dynamic condition. The scope of this paper is extending the general Fourier transform for increasing its response speed twelve times. Proposed approach named Very Fast Fourier Transform (VFFT) can be used in distorted three phase systems as a useful tool for reference generation of the UPQC. Results validate the proposed theory capability in reference generation and power quality compensation of a typical distribution system in sag, swell, and harmonized conditions in the presence of dynamic loads. Comparison between general and extended Fourier transform shows increase in the reference signal generation speed.

Keywords: Very Fast Fourier Transform (VFFT), UPQC, Power Quality, Dynamic Conditions.

I. INTRODUCTION

Nowadays, much of the equipments based on power electronic devices which are used by the industry, lead to power quality problems. These devices, which need high-quality energy to work properly, at the same time, are the most responsible ones for decreasing of power quality. In these conditions, both electric utilities and customers are increasingly affected from the quality of electric power [1]. Between the different technical approaches available for the compensation of power quality problems, Active Power Filters (APFs) have an important alternative to compensate the power quality problems [2-9].

In [10] various configurations of APFs are reported. One of the most efficient solution systems for power quality problems is the Unified Power Quality Conditioner (UPQC).

It consists of a Parallel-Active Filter (PAF) and a Series-Active Filter (SAF) together with a common dc link. This combination allows a simultaneous compensation for source side currents and delivered voltage to the load. In this way, operation of the UPQC isolates the utility from current quality problems of the load and at the same time isolates the load from the voltage quality problems of the utility [11-26].

Recently, major research area about UPQC has been carried out on reference generation circuit with the objective of fast response to obtain the switch control signals. The performance of the UPQC mainly depends on how accurately and quickly the reference signals are derived. Fourier transform is a useful method for reference signals generation of series and shunt APFs. But its disadvantage is slow response and week capability in dynamic condition.

The scope of this research is the extension of Fourier transform for increasing its response speed in extraction of the first order components magnitude and phase in three phase systems. Extended approach has been named Very Fast Fourier Transform (VFFT). In the proposed approach for fast response as well as good steady state response, there are two different data window lengths, $\frac{T}{12}$ and $\frac{T}{2}$; where, T is the main period. In the voltage sag, swell and load change conditions data window length is setup to $\frac{T}{12}$, but in the steady state condition it is arranged to $\frac{T}{2}$.

Section II generally introduces UPQC and its equivalent circuit. Section III explains proposed VFFT and related equations. Section IV introduces UPQC reference generation system based on the proposed VFFT approach. Section V simulates the proposed algorithm. In this section increase in response speed of the proposed VFFT in comparison with general Fourier transform has been shown. Finally, section VI concludes the results.

II. CONFIGURATION

UPQC has composed of two series and parallel APFs that are connected back to back and are controlled for instantaneously. The shunt APF which acts as a current source inverter is responsible for the load current harmonics compensation as well as reactive power. It is connected to the grid via a second order LC filter and parallel star connection transformer. Also, the series PAF which acts as voltage source inverter is responsible for the source voltage sag, swell, unbalance and harmonics compensation. It is connected to the grid via a second order low pass LC filter and three series single phase transformer. Second order filters are used to reduce the inverter switching frequencies. Figure 1 shows a simple schematic of a UPQC.

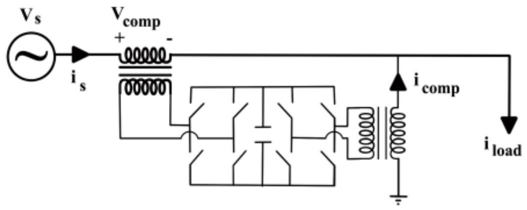

Figure 1. General schematic of a UPQC

Equivalent single phase representation of the UPQC is shown in Figure 2. Series active filter can be modeled as the voltage source and parallel active filter can be modeled as the current source. Related Kirchhoff's current and voltage lows are as Equation (1).

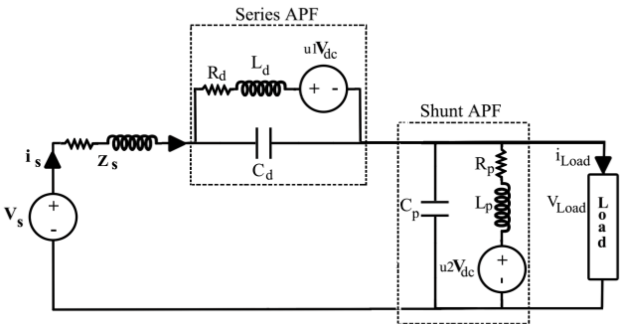

Figure 2. Circuit model of UPQC

$$\begin{aligned} i_s &= i_L - i_{sh} \\ v_s &= v_L + v_{se} \end{aligned} \quad (1)$$

where, i_{sh} is the shunt APF current and v_{se} is the series APF voltage.

III. PROPOSED VERY FAST FOURIER TRANSFORM

Fourier transform has the capability of different order components extraction of distorted periodic voltages and currents. Positive first order components of voltages and currents can be used for generating the reference signals. Based on the general equations of Fourier transform, settling time is one cycle which causes week capability in dynamic conditions.

Proposed extended Fourier transform will be responsible for improving this problem. First order components of a signal can be written as Equations (1) and (2).

$$a_1 = \frac{2}{2\pi}\int_0^{2\pi} v(\omega t)\cos(\omega t)d\omega t = \frac{4}{2\pi}\int_0^{\pi} v(\omega t)\cos(\omega t)d\omega t \quad (1)$$

$$b_1 = \frac{2}{2\pi}\int_0^{2\pi} v(\omega t)\sin(\omega t)d\omega t = \frac{4}{2\pi}\int_0^{\pi} v(\omega t)\sin(\omega t)d\omega t \quad (2)$$

It is assumed that $v(\omega t) = \sin(\omega t + \varphi)$, so it can be resulted for any amount of φ:

$$\frac{4}{2\pi}\int_0^{\pi} \sin(\omega t + \varphi)\cos(\omega t)d\omega t = \sin\varphi \quad (3)$$

and,

$$\begin{aligned} &\frac{8}{2\pi}\int_0^{\frac{\pi}{6}} \sin(\omega t+\varphi)\cos(\omega t)d\omega t + \\ &+\frac{8}{2\pi}\int_{\frac{2\pi}{6}}^{\frac{3\pi}{6}} \sin(\omega t+\varphi)\cos(\omega t)d\omega t + \\ &+\frac{8}{2\pi}\int_{\frac{4\pi}{6}}^{\frac{5\pi}{6}} \sin(\omega t+\varphi)\cos(\omega t)d\omega t = \sin\varphi \end{aligned} \quad (4)$$

So, Equations (5) and (6) can be result in:

$$\begin{aligned} &\frac{4}{2\pi}\int_0^{\pi} \sin(\omega t+\varphi)\cos(\omega t)d\omega t = \\ &= \frac{8}{2\pi}\int_0^{\frac{\pi}{6}} \sin(\omega t+\varphi)\cos(\omega t)d\omega t + \\ &+\frac{8}{2\pi}\int_{\frac{2\pi}{6}}^{\frac{3\pi}{6}} \sin(\omega t+\varphi)\cos(\omega t)d\omega t + \\ &+\frac{8}{2\pi}\int_{\frac{4\pi}{6}}^{\frac{5\pi}{6}} \sin(\omega t+\varphi)\cos(\omega t)d\omega t = \sin\varphi \end{aligned} \quad (5)$$

$$\begin{aligned} &\frac{4}{2\pi}\int_0^{\pi} \sin(\omega t+\varphi)\sin(\omega t)d\omega t = \\ &= \frac{8}{2\pi}\int_0^{\frac{\pi}{6}} \sin(\omega t+\varphi)\sin(\omega t)d\omega t + \\ &+\frac{8}{2\pi}\int_{\frac{2\pi}{6}}^{\frac{3\pi}{6}} \sin(\omega t+\varphi)\sin(\omega t)d\omega t + \\ &+\frac{8}{2\pi}\int_{\frac{4\pi}{6}}^{\frac{5\pi}{6}} \sin(\omega t+\varphi)\sin(\omega t)d\omega t = \cos\varphi \end{aligned} \quad (6)$$

It can be possible rewrite of Equations (5) and (6) as Equations (7) and (8), respectively.

$$\begin{aligned} a_1 &= \frac{8}{2\pi}\int_0^{\frac{\pi}{6}} \sin(\omega t+\varphi)\cos(\omega t)d\omega t + \\ &+\frac{8}{2\pi}\int_0^{\frac{\pi}{6}} (-\sin(\omega t+\varphi-{}^{2\pi}\!/\!_3))(-\cos(\omega t-{}^{2\pi}\!/\!_3))d\omega t + \\ &+\frac{8}{2\pi}\int_0^{\frac{\pi}{6}} \sin(\omega t+\varphi+{}^{2\pi}\!/\!_3)\cos(\omega t+{}^{2\pi}\!/\!_3)d\omega t = \\ &= \frac{8}{2\pi}\int_0^{\frac{\pi}{6}} \sin(\omega t+\varphi)\cos(\omega t)d\omega t + \\ &+\frac{8}{2\pi}\int_0^{\frac{\pi}{6}} \sin(\omega t+\varphi+{}^{2\pi}\!/\!_3)\cos(\omega t+{}^{2\pi}\!/\!_3)d\omega t + \\ &+\frac{8}{2\pi}\int_0^{\frac{\pi}{6}} \sin(\omega t+\varphi-{}^{2\pi}\!/\!_3)\cos(\omega t-{}^{2\pi}\!/\!_3)d\omega t \end{aligned} \quad (7)$$

$$\begin{aligned}
b_1 &= \frac{8}{2\pi}\int_0^{\frac{\pi}{6}} \sin(\omega t+\varphi)\sin(\omega t)d\omega t + \\
&+\frac{8}{2\pi}\int_0^{\frac{\pi}{6}} (-\sin(\omega t+\varphi-2\pi/3))(-\sin(\omega t-2\pi/3))d\omega t + \\
&+\frac{8}{2\pi}\int_0^{\frac{\pi}{6}} \sin(\omega t+\varphi+2\pi/3)\sin(\omega t+2\pi/3)d\omega t = \\
&=\frac{8}{2\pi}\int_0^{\frac{\pi}{6}} \sin(\omega t+\varphi)\sin(\omega t)d\omega t + \\
&+\frac{8}{2\pi}\int_0^{\frac{\pi}{6}} \sin(\omega t+\varphi+2\pi/3)\sin(\omega t+2\pi/3)d\omega t + \\
&+\frac{8}{2\pi}\int_0^{\frac{\pi}{6}} \sin(\omega t+\varphi-2\pi/3)\sin(\omega t-2\pi/3)d\omega t
\end{aligned} \tag{8}$$

Above equations show that it is possible to extract the Fourier first order components of a balanced three phase signal by using of three phase voltages combination until $\frac{T}{12}$ sec. It means that the response speed will be increased twelve times. But, the problem of this is the unfiltered steady state oscillations in the response which is because of small data window length. Thus, for accessing the fast response, as well as good steady state response, proper composition of $\frac{T}{12}$ and $\frac{T}{2}$ data window lengths have been used. In other word, $\frac{T}{2}$ data window length acts as a low pass filter and proposed approach uses $\frac{T}{12}$ data window length in signal magnitude change instances, for accessing the fast response, and $\frac{T}{2}$ data window length in other times, for accessing the good response without oscillation.

IV. CONTROL SCHEME OF UPQC

Figure 3, shows the block diagram of the proposed VFFT based control approach. Based on the previous indications, the detection of sag, swell, and load change conditions are essential problem for proper control of the UPQC. In this paper, based on fast detection capability of proposed approach slope of the first order component magnitude of the voltage and current signals has been compared with a constant value for the detection of voltage sag, swell and load change. This is based on the facts that in these conditions, the slope of the signal magnitude changes.

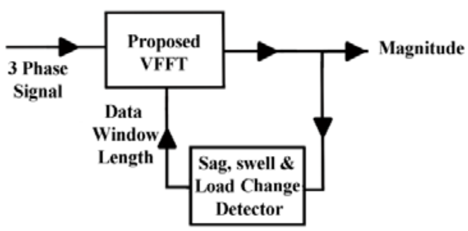

Figure 3. Proposed VFFT based control system

A. Series Active Filter Control Circuit

In this paper, the series APF operates as a controlled voltage source arranging the load voltage sinusoidal and at a predetermined constant voltage level. In this control approach, series active filter can compensate harmonics as well as voltage sag and swells. Proposed approach can be used for the extraction of direct and indirect first order components of the source side voltage. Thus the magnitude of reference load side voltage can be setup to the nominal value as Equation (9) for generation of desired load voltage. The series APF injects compensator voltage which is a voltage equal to the difference of the desired load voltage and the supply voltage to the grid. Figure 4 shows the block diagram of the series APF control circuit.

$$\begin{aligned}
v_1(t) &= a_1\cos(\omega t)+b_1\sin(\omega t) = \\
&= \sqrt{a_1^2+b_1^2}\,\sin(\omega t+\arctan\frac{a_1}{b_1})
\end{aligned} \tag{9}$$

$$v_{ref}(t) = v_{nom}\sin(\omega t+\arctan\frac{a_1}{b_1}) = v_{nom}\sin(\omega t+\varphi_{vl1})$$

where, φ_{vl1} is the first order component phase angle of the load voltage.

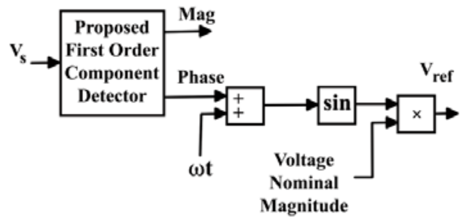

Figure 4. SAF control system block diagram

B. Parallel Active Filter Control Circuit

In this paper parallel active filter have the purpose of the reactive power compensation, as well as, current harmonics. The shunt APFs acts as a controlled current source. The shunt APF injects compensator current which is a current equal to the difference of the load current and the desired source current to the grid. For generation of desired source current active first order component of the load current which is tangent component of the load current to the load voltage can be used as Equation (10).

$$I_{ref}(t) = I_{l1}\cos(\varphi_{vl1}-\varphi_{il1})\sin(\omega t+\varphi_{vl1}) \tag{10}$$

where, I_{l1} and φ_{il1} are the first order component magnitude and phase angle of the load current, respectively. Figure 5 shows the block diagram of the shunt APF control circuit.

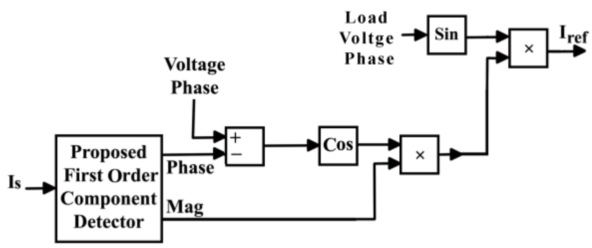

Figure 5. PAF control system block diagram

V. RESULTS

For the investigation of the validity of the proposed control strategy in reference generation and power quality compensation of a distribution system, simulation of the test circuit of Figure 6 has been done.

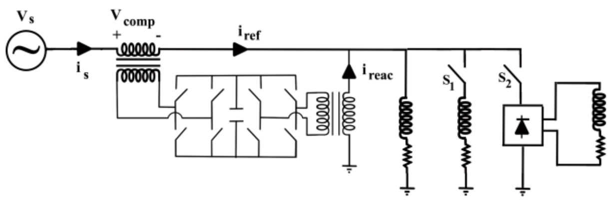

Figure 6. General test system circuit

This power system consists of a three phase 380 V (RMS, L-L), 50 Hz utility, two three phase linear R-L load and a three phase rectifier as a nonlinear load which are connected to the circuit at different times. This is for the investigation of the proposed control system capability in dynamic conditions. For the investigation of the voltage sag and swell conditions, utility voltages have 0.25 pu sag between 0.04 sec and 0.08 sec and 0.25 pu swell between 0.08 sec and 0.12 sec. Also, for the investigation of the proposed control strategy in the harmonic conditions, source voltage has been harmonized between 0.17 sec and 0.4 sec. Tables 1 and 2, shows the circuit parameters. In this study series active filter has been connected to the circuit at time zero. But, parallel active filter has been connected to circuit at time 0.25 sec.

Table 1. Utility voltage

Voltage	Time (sec)
$220\sqrt{2}\sin(\omega t)$	0-0.04, 0.12-0.17
$0.75\times 220\sqrt{2}\sin(\omega t)$	0.04-0.08
$1.25\times 220\sqrt{2}\sin(\omega t)$	0.08-0.12
$220\sqrt{2}\sin(\omega t)+(0.1)220\sqrt{2}\sin(3\omega t)+(0.1)220\sqrt{2}\sin(5\omega t-\pi/4)$	0.17-0.4

Table 2. Load powers and related switching times

Load	Nominal Power (kVA)	Nominal Voltage (RMS, L-L)	Switching Time (sec)
Linear	10	380 V	0
Linear	10	380 V	0.29
Non linear	5	380 V	0.29

Figure 7 shows the source and load side voltages of phase 1. In the load side voltage, sag and swell as well as harmonics have been compensated. Figure 8 shows compensator voltage of phase 1. Compensator voltage in sag, swell and harmonic conditions is nonzero. Voltage harmonics have been compensated in the load voltage. Figure 9 shows first order component magnitude of the source voltage extracted by T and $\frac{T}{2}$ data windows. Response speed in $\frac{T}{2}$ data window state has been increased twice.

Figure 10 shows the first order component magnitude of the source voltage extracted by the $\frac{T}{12}$ and composition of $\frac{T}{12}$ and $\frac{T}{2}$ data windows. Advantage of the proposed VFFT over the FFT and composition of $\frac{T}{12}$ and $\frac{T}{2}$ data windows over the $\frac{T}{12}$ data window can be viewed from Figure 10. In the proposed approach, settling time is 0.00166 sec and there is no oscillation in the response. Figure 11 shows the load and source side currents of phase 1 in presence of switched linear and nonlinear loads. Figure 12 shows the compensator current of phase 1 which is for reactive power as well as current harmonics compensation.

Current harmonics has been compensated in the source current. Figure 13 show first order component magnitude of the load current extracted by T and $\frac{T}{2}$ data windows. Figure 14 shows the first order component magnitude of the load current extracted by $\frac{T}{12}$ and composition of $\frac{T}{12}$ and $\frac{T}{2}$ data windows. Table 3 shows THDs of the source and load voltages and currents. Load voltage and source current harmonics have been compensated satisfactory.

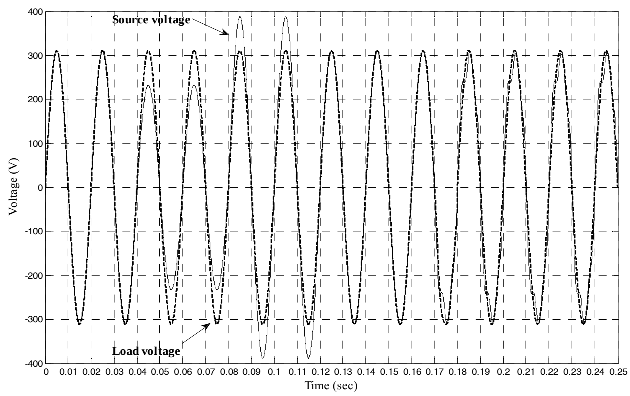

Figure 7. Source side voltage (solid line) and load side voltage (dashed line) of phase 1

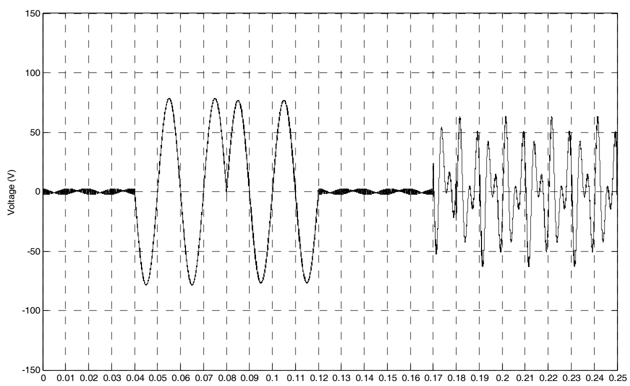

Figure 8. Compensator voltage

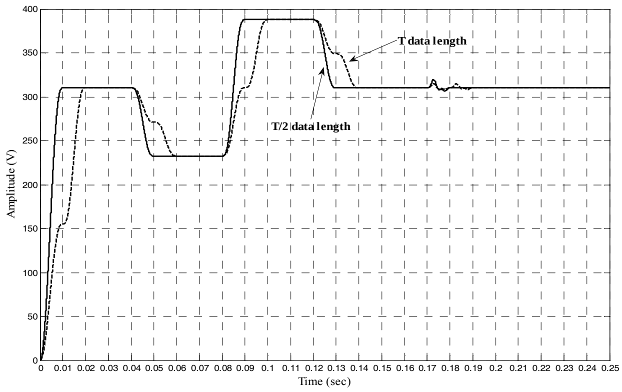

Figure 9. Extracted voltage magnitude by T (dashed line) and $T/2$ (solid line) data windows

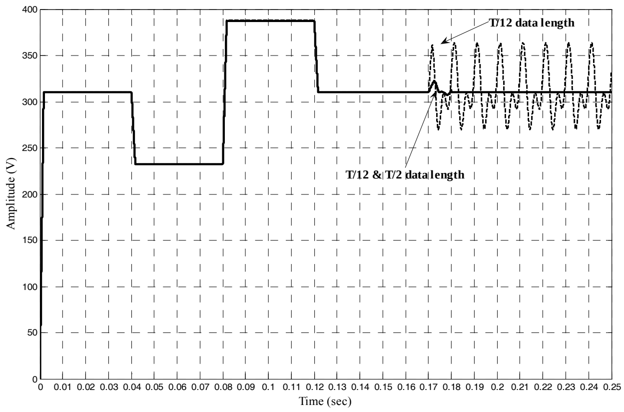

Figure 10. Extracted voltage magnitude by $T/12$ (dashed line) and composition of $T/12$ and $T/2$ (solid line) data windows

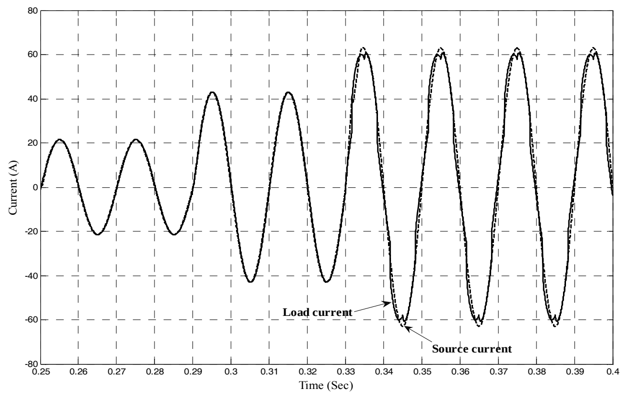

Figure 11. Load side current (solid line) and source side current (dashed line) of phase 1

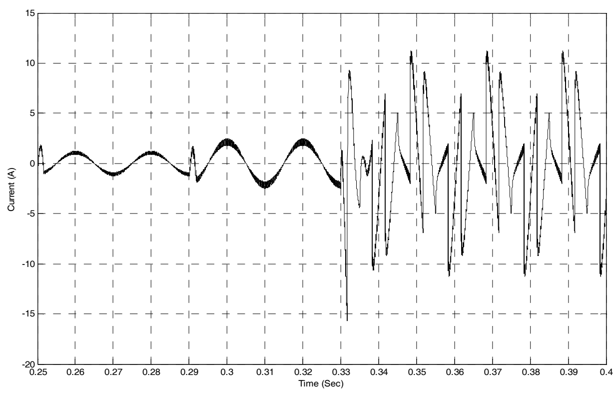

Figure 12. Compensator current

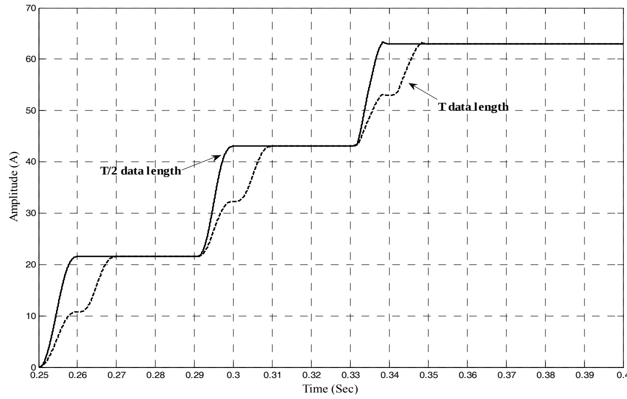

Figure 13. Extracted current magnitude by T (dashed line) and $T/2$ (solid line) data windows

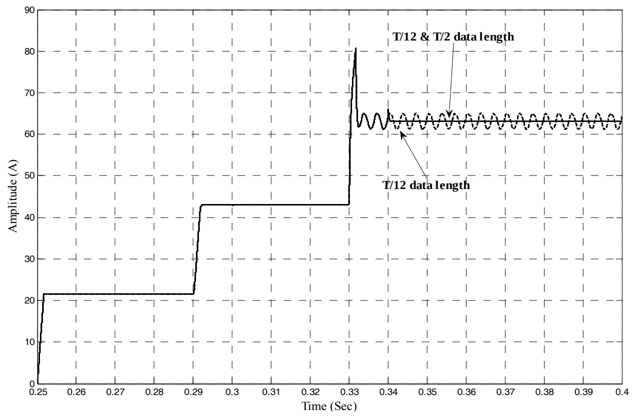

Figure 14. Extracted current magnitude by $T/12$ (dashed line) and composition of $T/12$ and $T/2$ (solid line) data windows

Table 3. Total Harmonic Distortion (THD)

Source Voltage THD (Percent)	Load Current THD (Percent)	Load Voltage THD (Percent)	Source Current THD (Percent)
14.14	9	Almost zero	Almost zero

VI. CONCLUSIONS

In this paper power quality compensation have been investigated in sag, swell, and harmonized conditions in the presence of dynamic loads via the UPQC. The proposed control system was based on the proposed extended Fourier transform theory. In this research for increasing the responsibility speed, Very Fast Fourier Transform (VFFT) approach has been proposed for balanced three phase systems. In the proposed approach, settling time of the response could be reduced to one twelfth of a cycle.

In the proposed approach, there were two data window lengths, $\frac{T}{12}$ and $\frac{T}{2}$. In the sag, swell, and load change conditions, control system was switched to $\frac{T}{12}$ for obtaining fast response. Then, for improving the proposed approach responsibility in filtering of unwanted steady state oscillation, control system was switched to $\frac{T}{2}$ for obtaining no oscillated response. In these states, fast response in dynamic conditions as well as good response in the steady state conditions would be possible.

In this research for the detection of the source voltage sag, swell, and load change conditions, slope of the first order magnitude of the voltage and current signal, were compared to a constant value. Proposed control approach was simulated in MATLAB/SIMULINK software. Voltage sag, swell, and harmonics were compensated by SAF. But, reactive power and current harmonics were compensated by PAF. THD of load voltage before compensation was 14.14 percent which was reduced to zero after the compensation. Also, THD of the source current before compensation was 9 percent which was reduced to zero after the compensation.

NOMENCLATURES

i_{sh} : The shunt APF current

v_{se} : The series APF voltage

i_L : The load current

v_s : The source current

v_{nom} : Nominal voltage magnitude

φ_{vl1} The first order component phase angle of the load voltage

I_{l1} : The first order component magnitude of the load current

φ_{il1} **:** The first order component phase angle of the load current

REFERENCES

[1] I. Axente, J.N. Ganesh, M. Basu, M.F. Conlon, K. Gaughan, "A 12-kVA DSP-Controlled Laboratory Prototype UPQC Capable of Mitigating Unbalance in Source Voltage and Load Current", IEEE Transactions on Power Delivery, Issue 6, Vol. 25, pp. 1471-1479, 2010.

[2] M.I. Arei, E.F. El-Saadany, M.M. Salama, "A Novel Control Algorithm for the DG Interface to Mitigate Power Quality Problems", IEEE Transaction on Power Delivery, Issue 3, Vol. 19, pp. 1384-1392, July 2004.

[3] H. Shayeghi, H.A. Shayanfar, F. Shalchi, "Robust Loop-Shaping Based Pod Controller Design for UPFC", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 3, Vol. 2, No. 2, pp. 45-51, June 2010.

[4] N.M. Tabatabaei, A. Hashemi, N. Taheri, F.M. Sadikoglu, "A Novel on Line Adaptive Based Stabilizer for Dynamic Stability Improvement with UPFC", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 8, Vol. 3, No. 3, pp. 93-99, September 2011.

[5] H. Akagi, "Instantaneous Power Theory and Applications to Power Conditioning", Wiley, New York, 2007.

[6] M.J. Newman, D.G. Holmes, J.G. Nielsen, F. Blaabjerg, "A Dynamic Voltage Restorer (DVR) with Selective Harmonic Compensation at Medium Voltage Level", IEEE Transaction on Industrial Applications, Issue 6, Vol. 41, pp. 1744-1753, Nov./Dec. 2005.

[7] J.G. Nielsen, F. Blaabjerg, "A Detailed Comparison of System Topologies for Dynamic Voltage Restorers", IEEE Transaction on Industrial Applications, Issue 5, Vol. 41, pp. 1272-1280, Sep./Oct. 2005.

[8] J.G. Nielsen, M. Newman, H. Nielsen, F. Blaabjerg, "Control and Testing of a Dynamic Voltage Restorer (DVR) at Medium Voltage Level", IEEE Transaction on Power Electronic, Issue 3, Vol. 19, pp. 806-813, May 2004.

[9] M.J. Newman, D.N. Zmood, D.G. Holmes, "Stationary Frame Harmonic Reference Generation for Active Filter Systems", IEEE Transaction on Industrial Applications, Issue 6, Vol. 38, pp. 1591-1599, Nov./Dec. 2002.

[10] A. Ghosh, G. Ledwich, "Power Quality Enhancement Using Custom Power Devices", MA: Kluwer, Boston, 2002.

[11] H. Fujita, H. Akagi, "The Unified Power Quality Conditioner: The Integration of Series and Shunt Active Filters", IEEE Transaction on Power Electronics, Issue 3, Vol. 13, pp. 315-322, 1998.

[12] M.A. Hannan, A. Mohamed, "PSCAD/EMTDC Simulation of Unified Series-Shunt Compensator for Power Quality Improvement", IEEE Transaction on Power Delivery, Issue 2, Vol. 20, pp. 1650-1656, 2005.

[13] V. Khadkikar, A. Chandra, "A Novel Structure for Three Phase Four Wire Distribution System Utilizing Unified Power Quality Conditioner (UPQC)", IEEE Transactions on Industry Applications, Issue 5, Vol. 45, pp. 1897-1902, 2009.

[14] K.H. Kwan, Y.C. Chu, P.L. So, "Model-Based H∞ Control of a Unified Power Quality Conditioner", IEEE Transactions on Industrial Electronics, Issue 7, Vol. 56, pp. 2493-2504, 2009

[15] V. Khadkikar, A. Chandra, "A New Control Philosophy for a Unified Power Quality Conditioner (UPQC) to Coordinate Load-Reactive Power Demand Between Shunt and Series Inverters", IEEE Trans. on Power Delivery, Issue 4, Vol. 23, pp. 2522-2534, 2008.

[16] W.C. Lee, D.M. Lee, T.K. Lee, "New Control Scheme for a Unified Power Quality Compensator-Q with Minimum Active Power Injection", IEEE Transaction on Power Delivery, Issue 2, Vol. 25, pp. 1068-1076, 2010.

[17] B. Han, B. Bae, H. Kim, S. Baek, "Combined Operation of Unified Power-Quality Conditioner with Distributed Generation", IEEE Transaction on Power Delivery, Issue 1, Vol. 21, pp. 330-338, 2006.

[18] H.R. Mohammadi, A.Y. Varjani, H. Mokhtari, "Multiconverter Unified Power-Quality Conditioning System: MC-UPQC", IEEE Transaction on Power Delivery, Issue 3, Vol. 24, pp. 1679-1686, 2009.

[19] A.K. Jindal, A. Ghosh, A. Joshi, "Interline Unified Power Quality Conditioner", IEEE Transaction on Power Delivery, Issue 1, Vol. 22, pp. 364-372, 2007.

[20] H.A. Shayanfar, A. Mokhtarpour, "Management, Control and Automation of Power Quality Improvement", INTECH Book Company, Austria, 2010.

[21] A. Mokhtarpour, H.A. Shayanfar, N.M. Tabatabaei, "Power Quality Compensation in Two Independent Distribution Feeders", Int. Journal for Knowledge, Science and Technology, Vol. 1, No. 1, pp. 98-105, 2009.

[22] H.A. Shayanfar, N.M. Tabatabaei, A. Mokhtarpour, "Best Control Strategy for Unified Power Quality Conditioner (UPQC) Based on Simulation", The IASTED International Conference on Power and Energy Systems (PES 2007), pp. 257-262, Clearwater, Florida, USA, January 2007.
[23] A. Kazemi, A. Mokhtarpour, M. Tarafdar Haque, "A New Control Strategy for Unified Power Quality Conditioner (UPQC) in Distribution Systems", IEEE International Conference on Power System Technology (POWERCON 2006), pp. 1-5, October 2006.
[24] H.A. Shayanfar, N.M. Tabatabaei, A. Mokhtarpour, "Modified Strategy for Unified Power Quality Conditioner (UPQC) Based on Intelligent Devices", The Ninth World Multiconference on Systemic, Cybernetics and Informatics, Vol. IX, pp. 13-17, Orlando, Florida, USA, July 2005.
[25] H. Heydari, A.H. Moghadasi, "Optimization Scheme in Combinatorial UPQC and SFCL Using Normalized Simulated Annealing", IEEE Transactions on Power Delivery, Issue 3, Vol. 26, pp. 1489-1498, 2011.
[26] L.H. Tey, P.L. So, Y.C. Chu, "Neural Network Controlled Unified Power Quality Conditioner for System Harmonic Compensation", IEEE Power Eng. Soc. Transmission and Distribution Conf. and Exhibit. Asia Pacific, Vol. 2, pp. 1038-1043, October 2002.

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