Power Quality Improvement by Unified Power Quality Conditioner

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Abstract- *In This paper we use UPQC configuration and its various control strategies along with need of UPQC clarification. Among from various methods, synchronous reference frame based control method for series active filter and Instantaneous pq Theory for Shunt Active Filter. Dynamic model of series active filter and shunt active power filter built in MATLAB simulation and results are illustrated.*

Keywords- Basic block diagram of UPQC. MATLAB Model of UPQC, Simulation and Results.

I. INTRODUCTION

Power quality is the superiority of the electrical power supplied to electrical equipment. It determines the fitness of electrical power. Synchronization of the voltage frequency and phase allows electrical systems to function in their intended manner without significant loss of performance or life. Though the modem power system is becoming highly vulnerable to the different power quality problems. The main causes of a poor power quality are harmonic currents, poor power factor, supply-voltage variations, etc. The extensive use of non-linear loads is contributing to increased current and voltage harmonics issues. Furthermore, the penetration level of small/large-scale renewable energy systems based on wind energy, solar energy, fuel cell, etc., installed at distribution as well as transmission levels is increasing power quality problems significantly. Furthermore, Regulation & guidelines of reactive power and harmonic are upcoming issues in distributed power system and industries. By the continuous efforts of power electronics researchers and engineers, it is expected that very soon customer will get high efficient, high quality and reliable power by using power electronics technology.

II. POWER QUALITY ISSUE

The power quality issue is defined as "any occurrence of disturbance in voltage, current or frequency that results in equipment overheating, misbehaving of equipment or damage device". Almost all power quality issues are closely related with power electronics in almost every aspect of commercial, domestic, and industrial application. Equipments like computers, copiers, printers, programmable logic controllers, adjustable speed drives (ASDs), rectifiers, inverters etc. are the example of power electronics devices.

Major issues of poor power quality are as bellow:

- Voltage sag
- Voltage swell
- Transients
- Voltage imbalance
- Voltage Flicker
- Voltage waveform Distortion
- Harmonic Reduction

III. METHODOLOGY & OBJECTIVE OF RESEARCH

Depending on the particular application or electrical problem to be solved, active power filters can be implemented as shunt type, series type, or a combination of shunt and series active filters (UPQC). These filters can also be combined with passive filters to create hybrid power filters. The series-shunt active filter is a combination of the series active filter and the shunt active filter. The shunt active filter is located at the load side and can be used to compensate for the load harmonics. On the other hand, the series portion is at the source side and can act as a harmonic blocking filter. This topology has been called the Unified Power Quality conditioner (UPQC). The series portion compensates for supply voltage harmonics and voltage unbalances, acts as a harmonic blocking filter, and damps power system oscillations. The shunt portion compensates load current harmonics, reactive power, and load current unbalances. In addition, it regulates the dc link capacitor voltage. Moreover one of the serious problems in electrical systems is the increasing number of electronic components of devices that are used by industry as well as residences. These devices, which need high-quality energy to work properly. At the same time, they are the most responsible ones for injections of harmonics in the distribution system. Therefore, devices that soften this drawback have been developed. One of them is the unified power quality conditioner. UPQC has the capability of improving power quality at the point of common coupling on power systems. So, the UPQC is expected to be one of the most powerful solutions to large capacity loads sensitive to supply voltage flicker/imbalance.

IV. UPQC CONFIGURATION

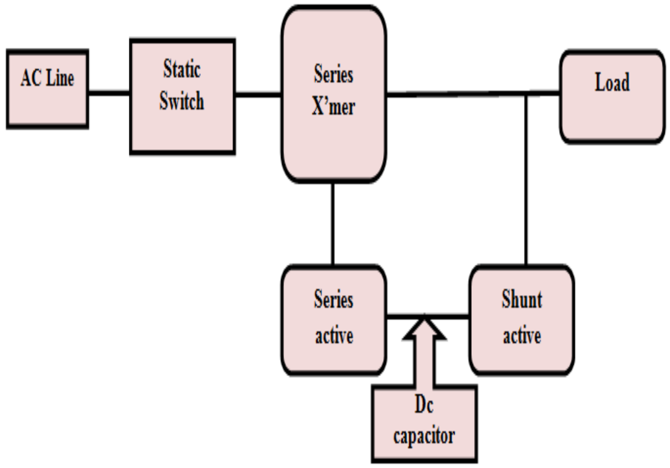

Fig.1 Block Diagram of UPQC

Unified power quality conditioners (UPQC) are ideal devices to improve power quality. It is also known as universal active filters. A combination of series and shunt active filters forms UPQC.

It has the capability of improving power quality at the point of common coupling on power systems. Therefore, The UPQC is expected to be one of the most powerful solutions to supply voltage flicker/imbalance introduced by large capacity loads.

The UPQC configuration is shown in fig.1. It consists of the combination of a series APF and shunt APF. Single-phase voltage controlled VSI used as a series active filter and a single-phase current controlled VSI used as a shunt active filter. The dc link of both active filters is connected to a common dc link capacitor. Series active filter suppresses and isolates voltage based distortions. The series APF is connected via a transformer in series with the AC line. Shunt active filter cancels current-based distortions. At the same time, it compensates reactive current of the load and improves power factor of the system. The shunt bi-directional converter is connected in parallel with the load terminals.

IV. UNIFIED POWER QUALITY CONDITIONER

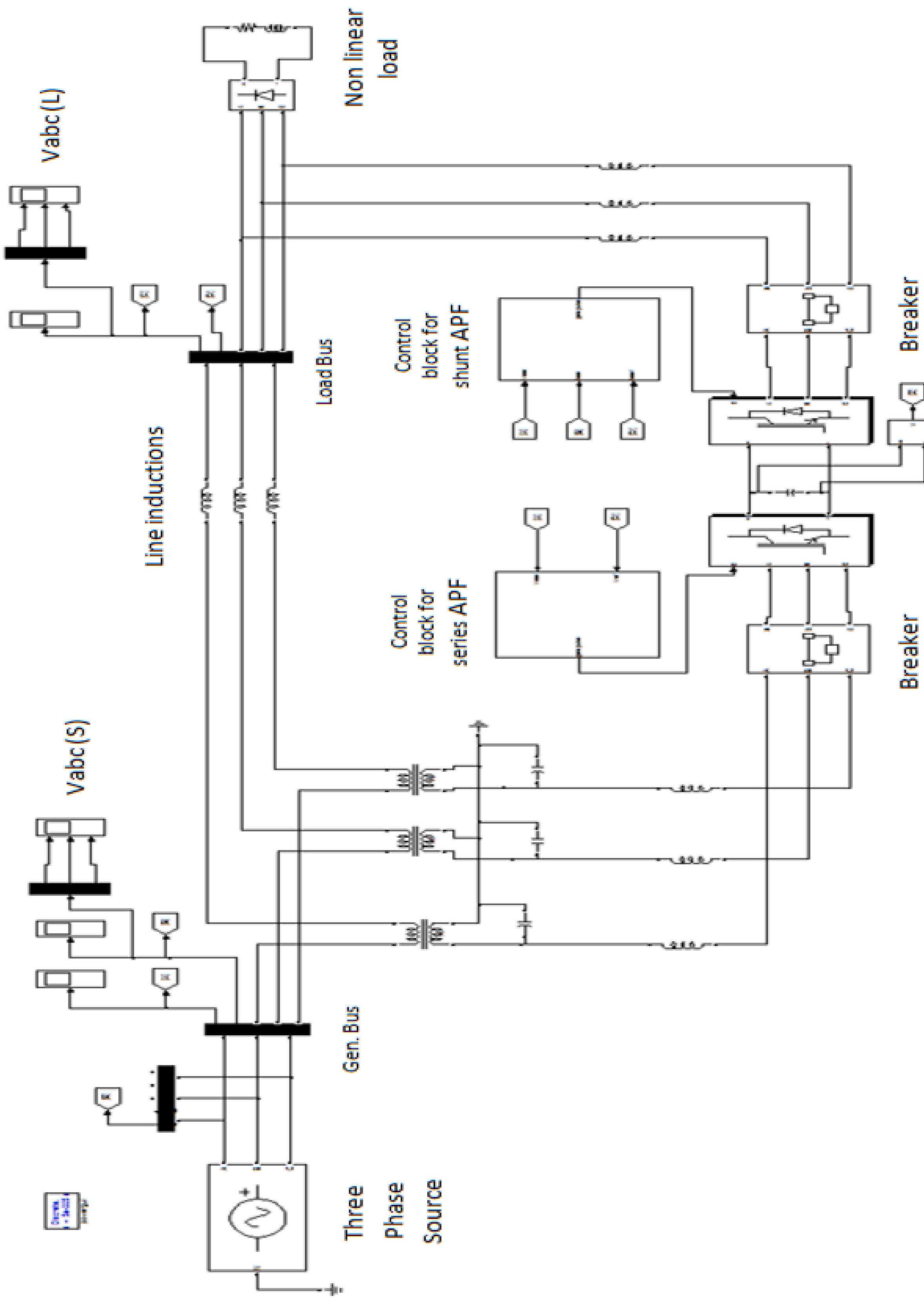

Fig. 2 Simulation Block Diagram of Unified Power Quality Conditioner in SIMULINK

V. SYNCHRONOUS REFERENCE FRAME BASED CONTROL CIRCUIT

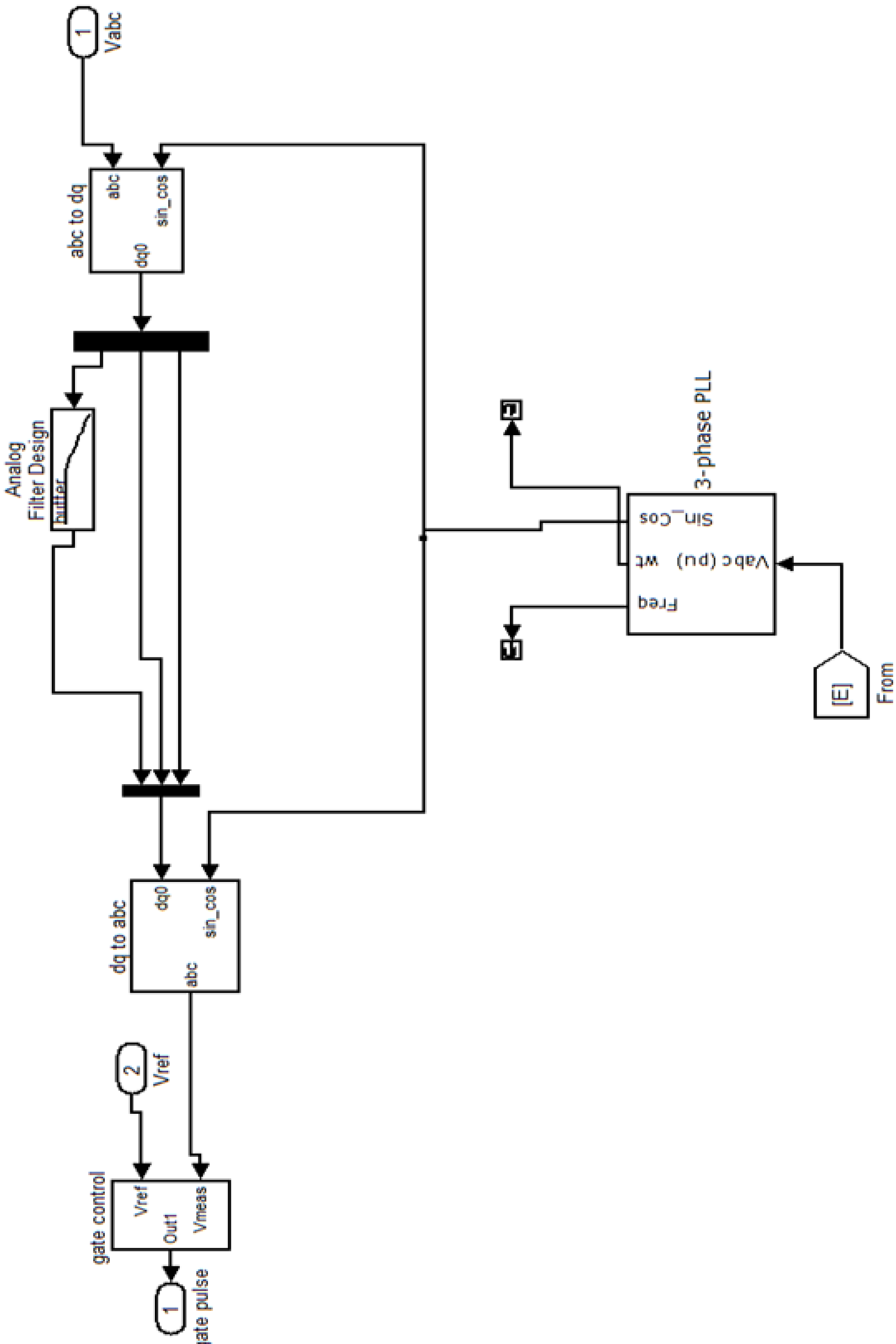

Fig.3 Control Block of Series Active Filter

VI. INSTANTANEOUS PQ THEORY BASED CONTROL CIRCUIT

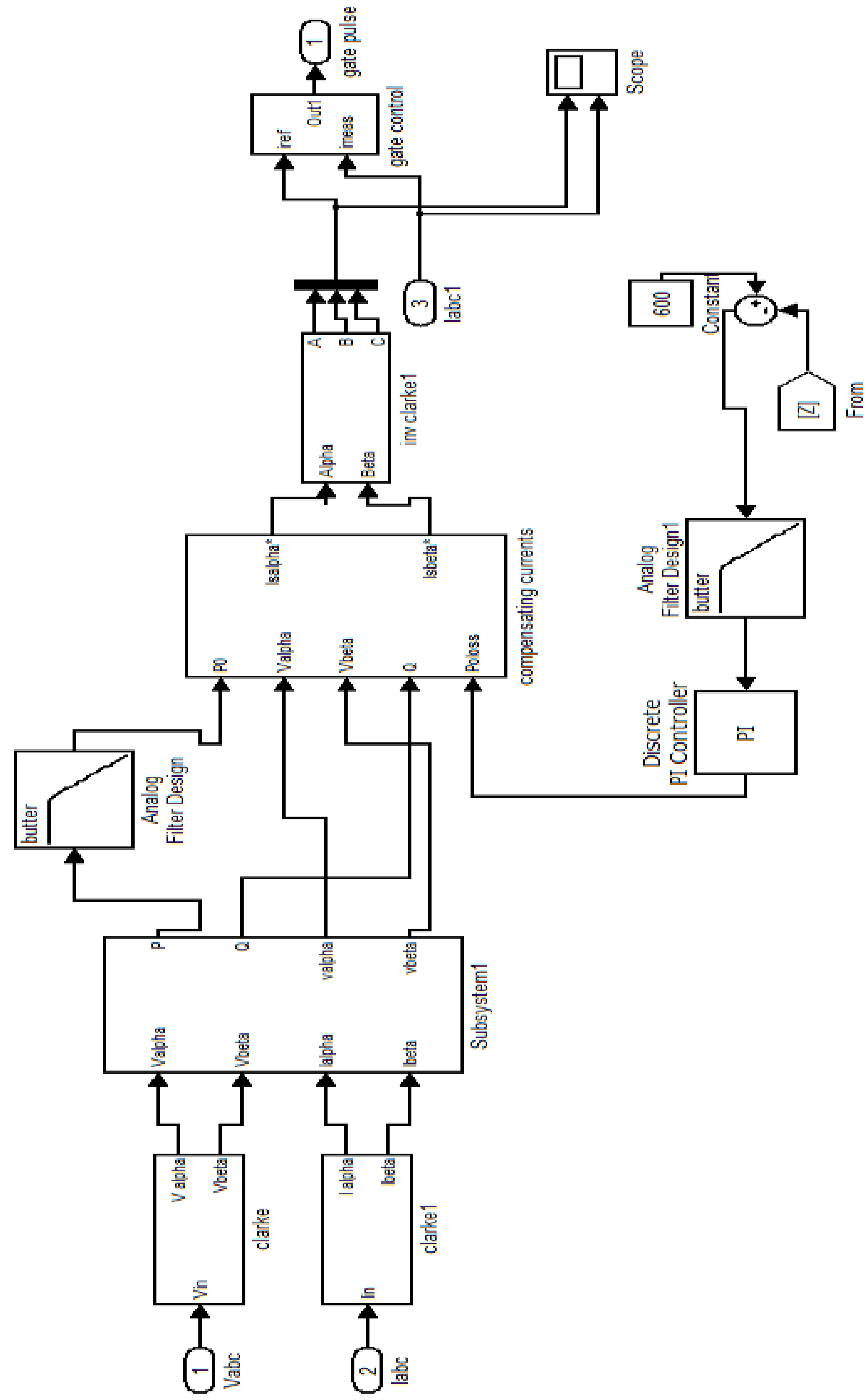

Fig. 4 Control Block of Shunt Active Filter

VII. HYSTERESIS VOLTAGE CONTROL LOOP

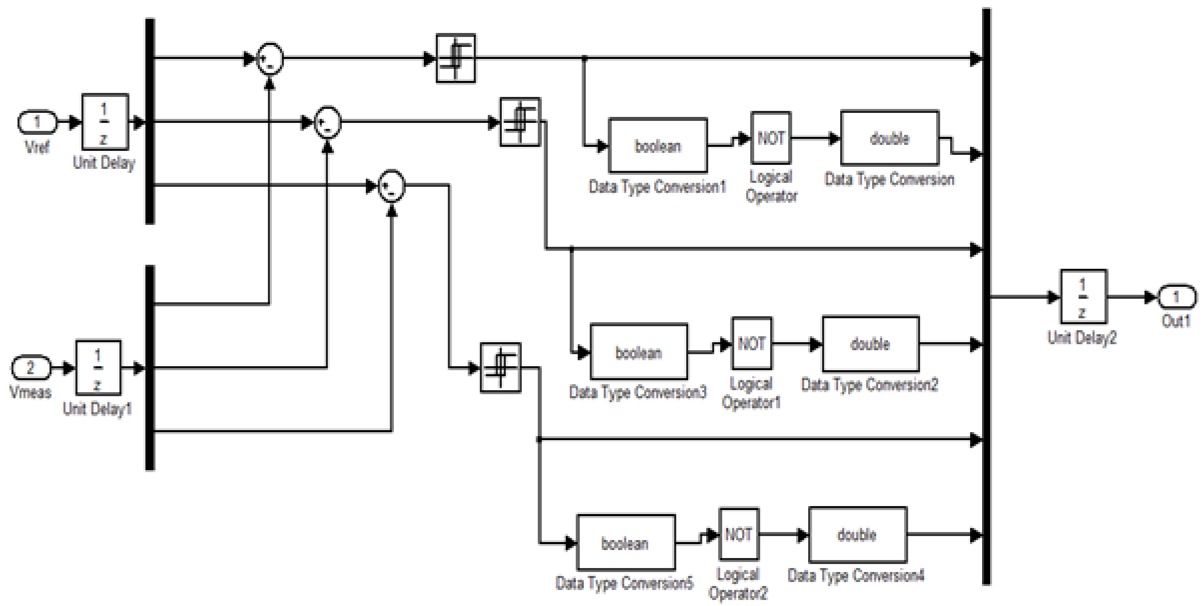

Fig. 5 Pulse Generator **-** Hysteresis Voltage Control Circuit

VIII. HYSTERESIS CURRENT CONTROL LOOP

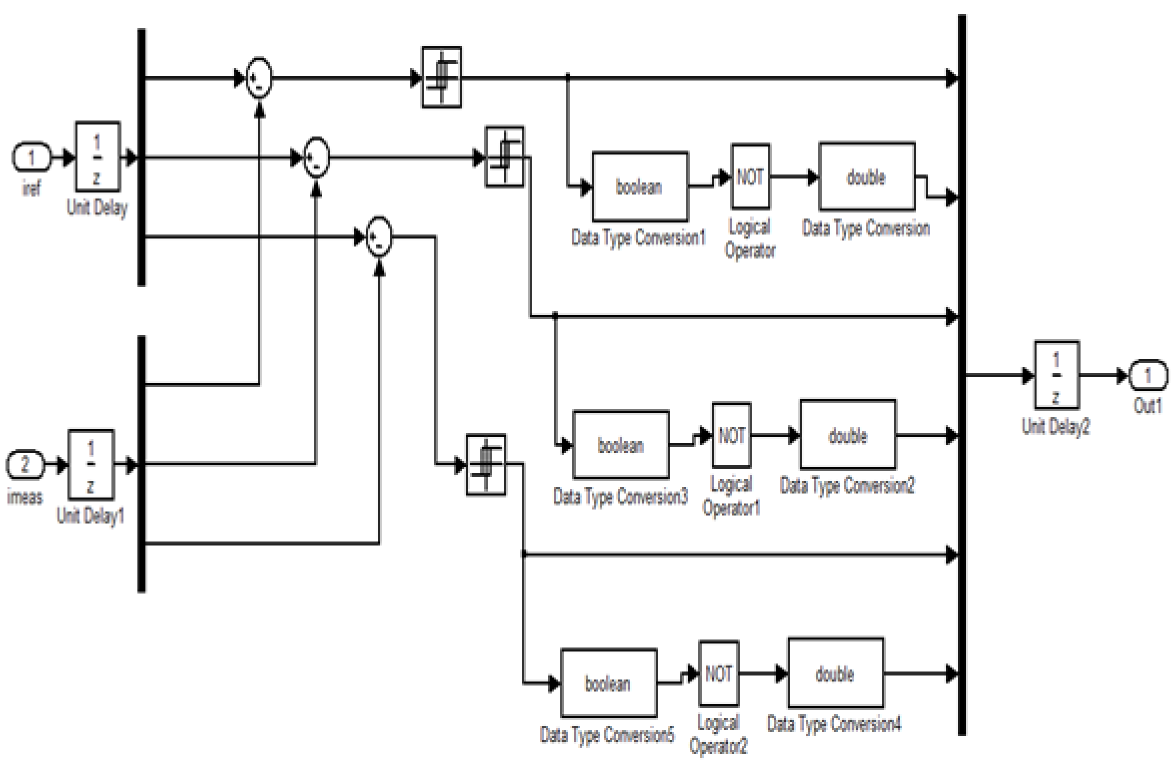

Fig. 6 Pulse Generator **-** Hysteresis Current Control Circuit

IX. SIMULATION PARAMETER OF UPQC

Table 1 Parameters of Proposed System (UPQC)

	Parameter	Value
Supply	Fundamental voltage Frequency	440 V 50 HZ
Load	Inductance Resistance	10 mH 100 Ω
Transformer	Nominal power Winding	0.01 MVA 440/440 (1:1)
Line	Inductance	1 mH
Series APF	Filter inductance Filter capacitance	0.4 mH 25 µF
Shunt APF	Filter inductance	1 Mh
DC Link	Capacitance Reference value of voltage	2200 µF 600

X. RESULTS OF UPQC

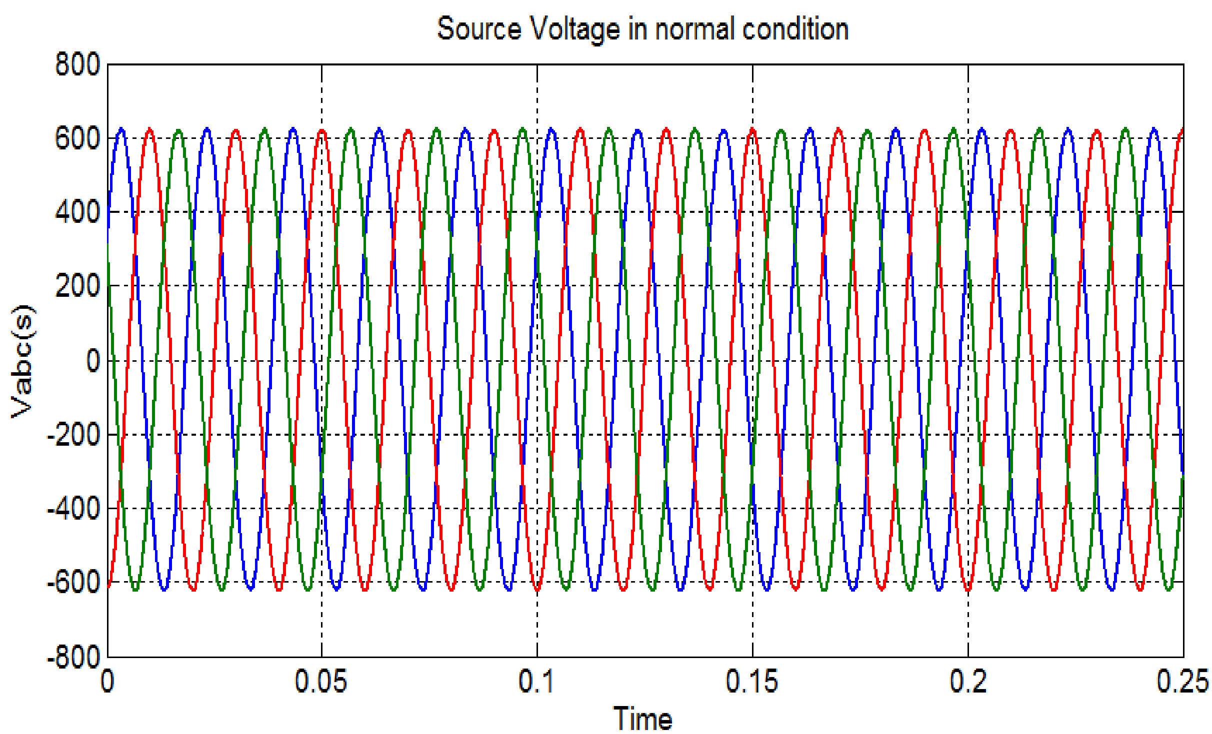

Fig. 7 System Voltage in Normal Condition

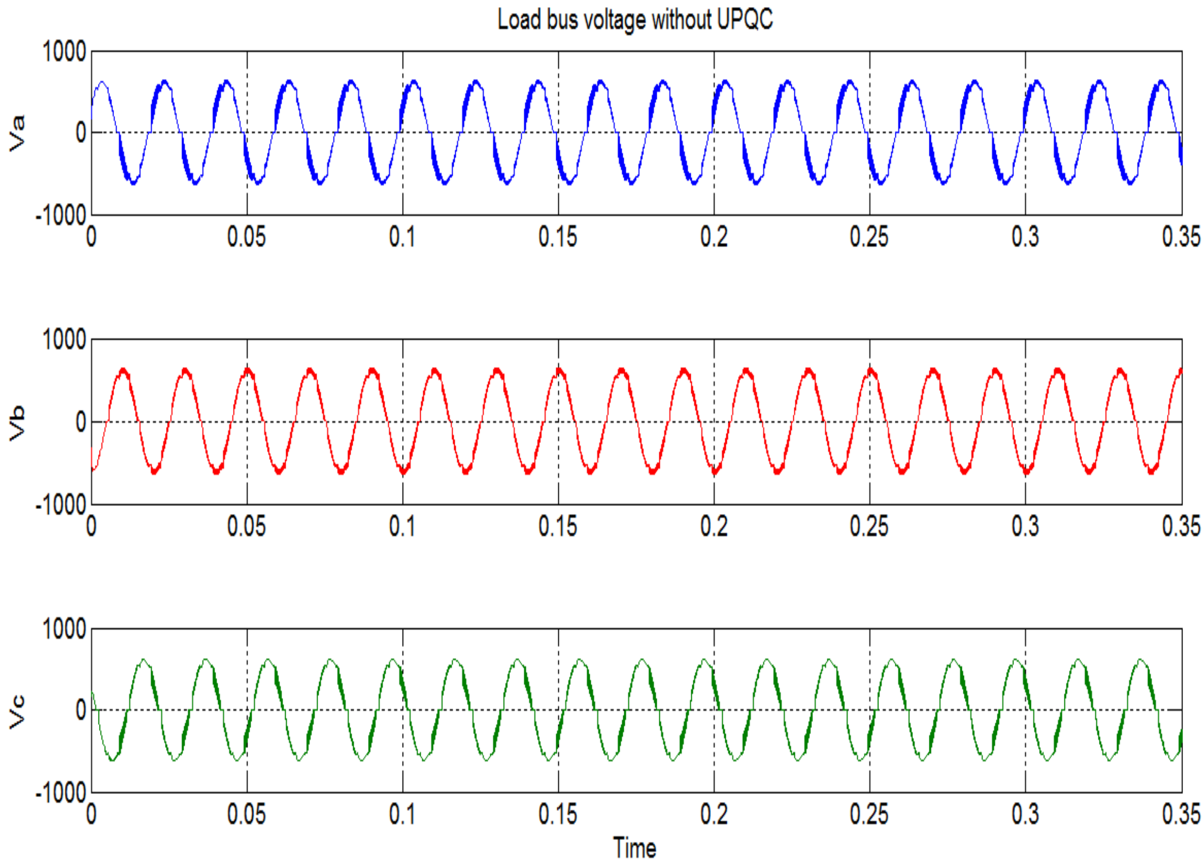

Fig. 8 Load Bus Voltage without UPQC

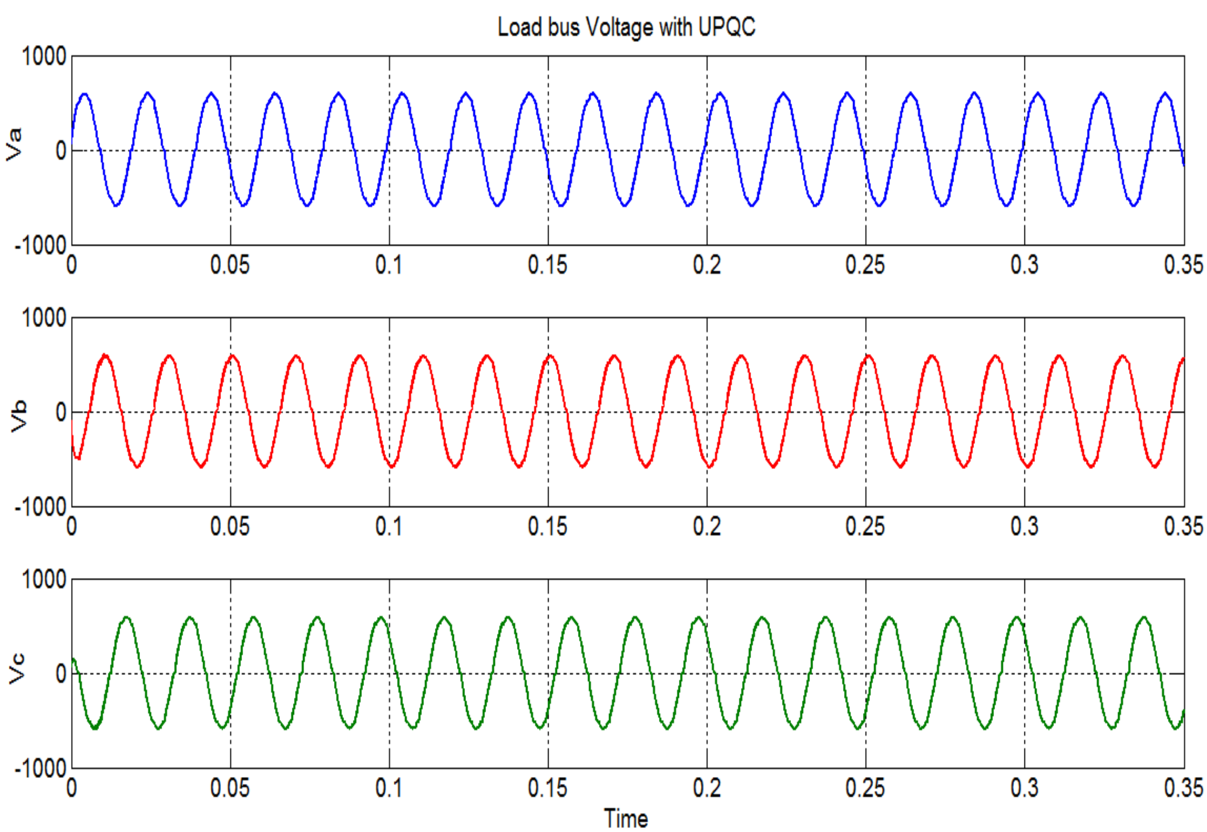

Fig. 9 Load Bus Voltage with UPQC

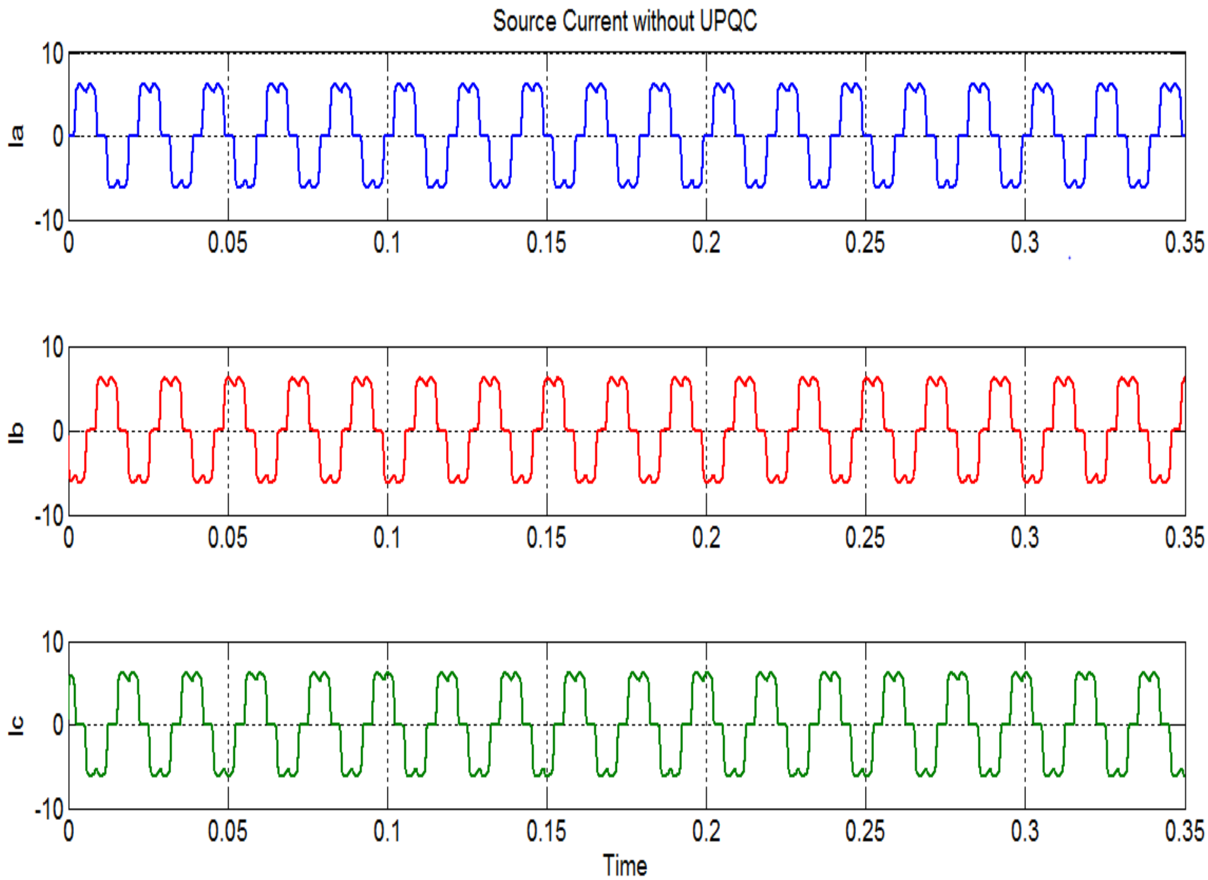

Fig. 10 Source Side Current without UPQC

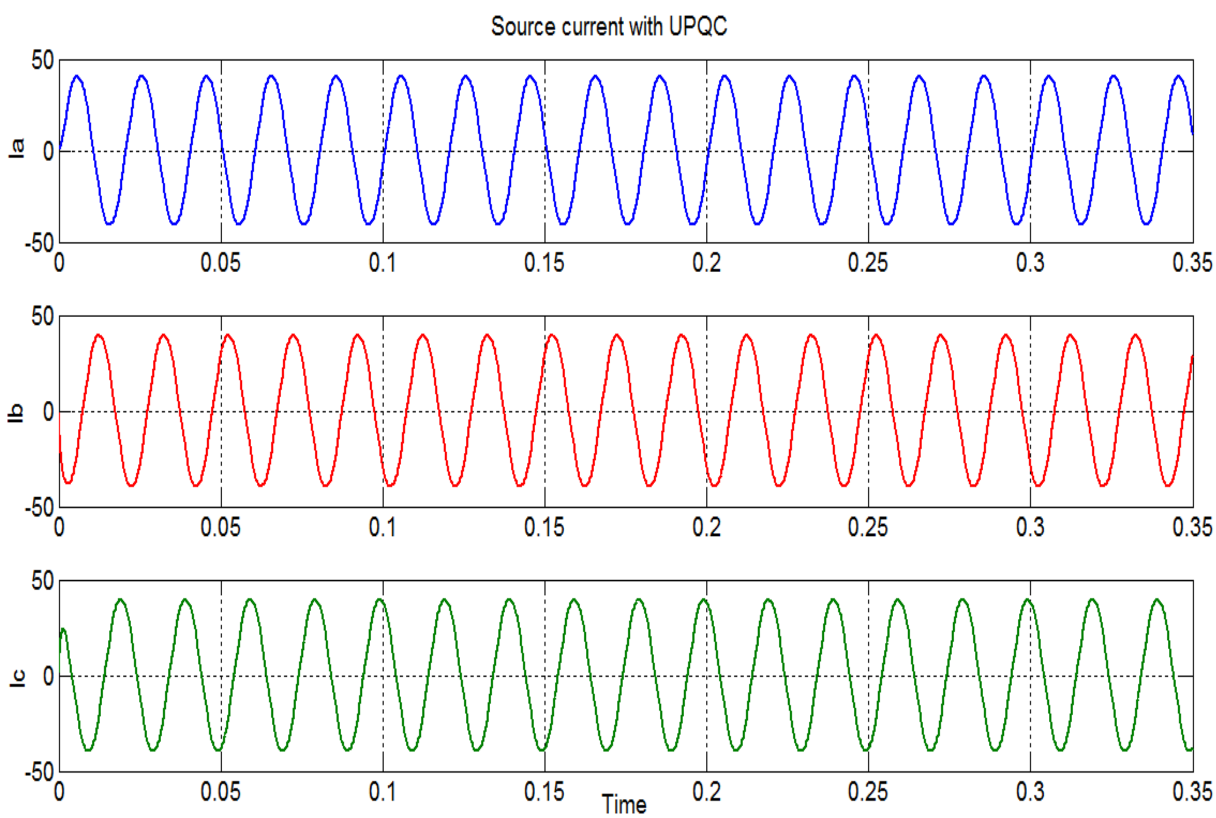

Fig. 11 Source Side Current with UPQC

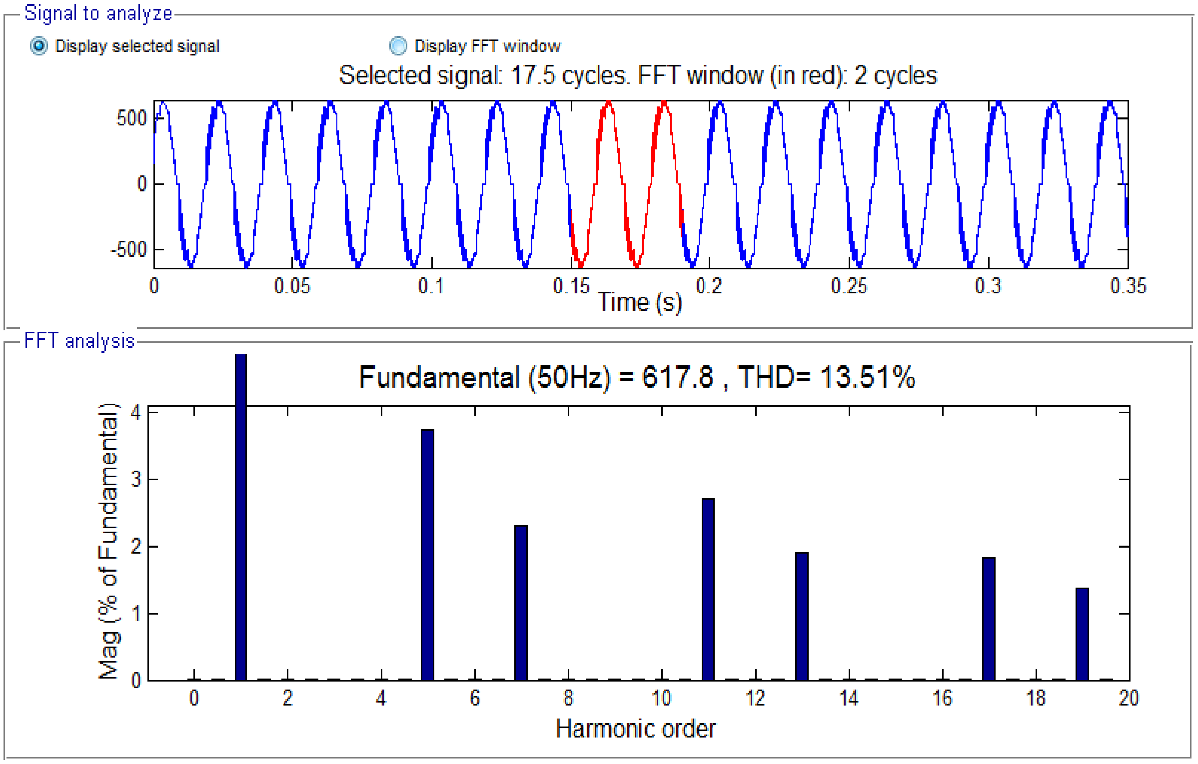

Fig. 12 Voltage THD of System without UPQC

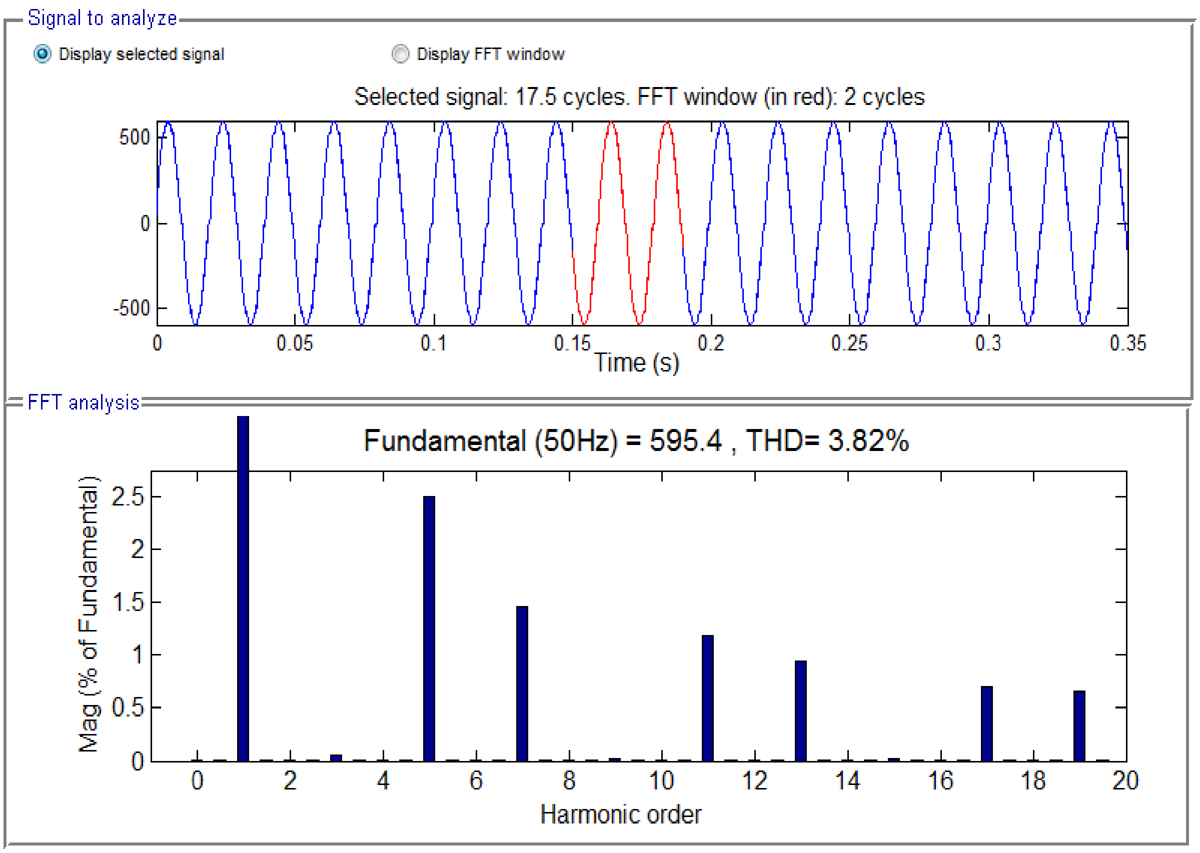

Fig. 13 Voltage THD of System with UPQC

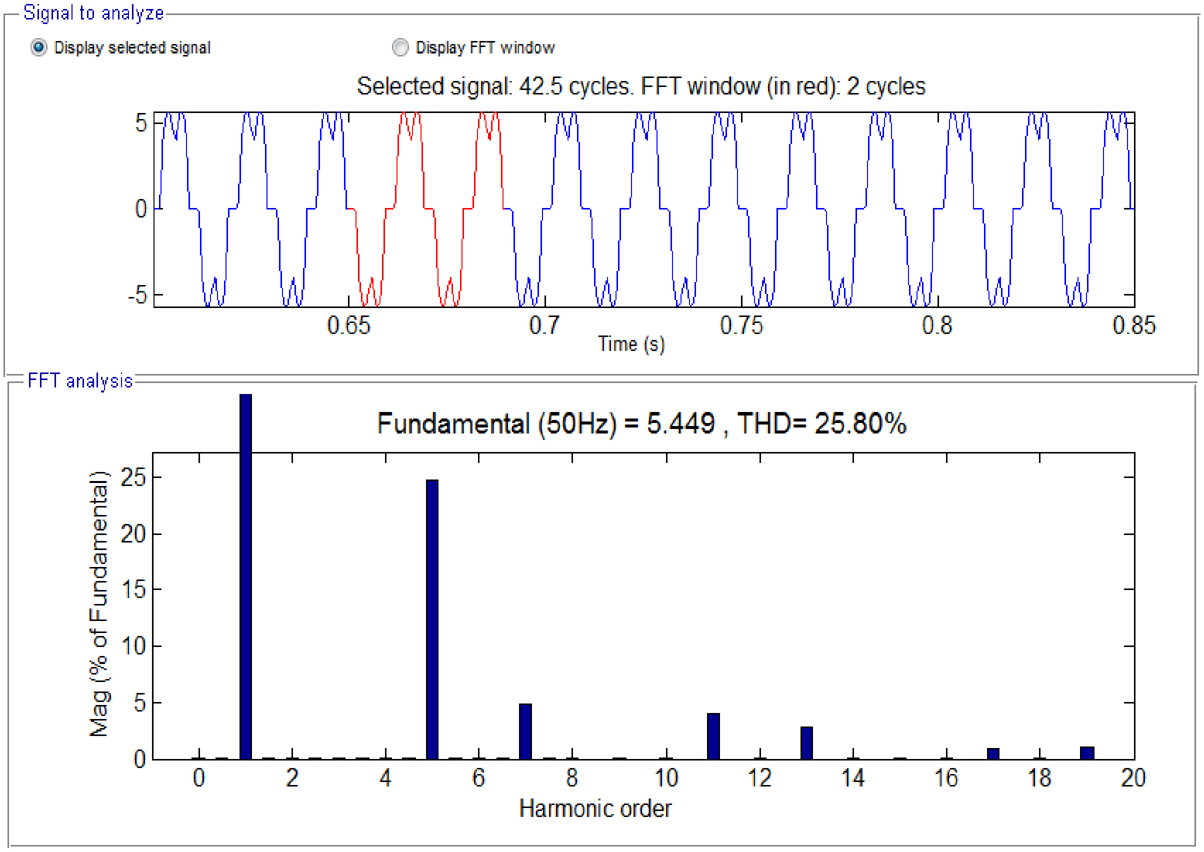

Fig. 14 Current THD of System without UPQC

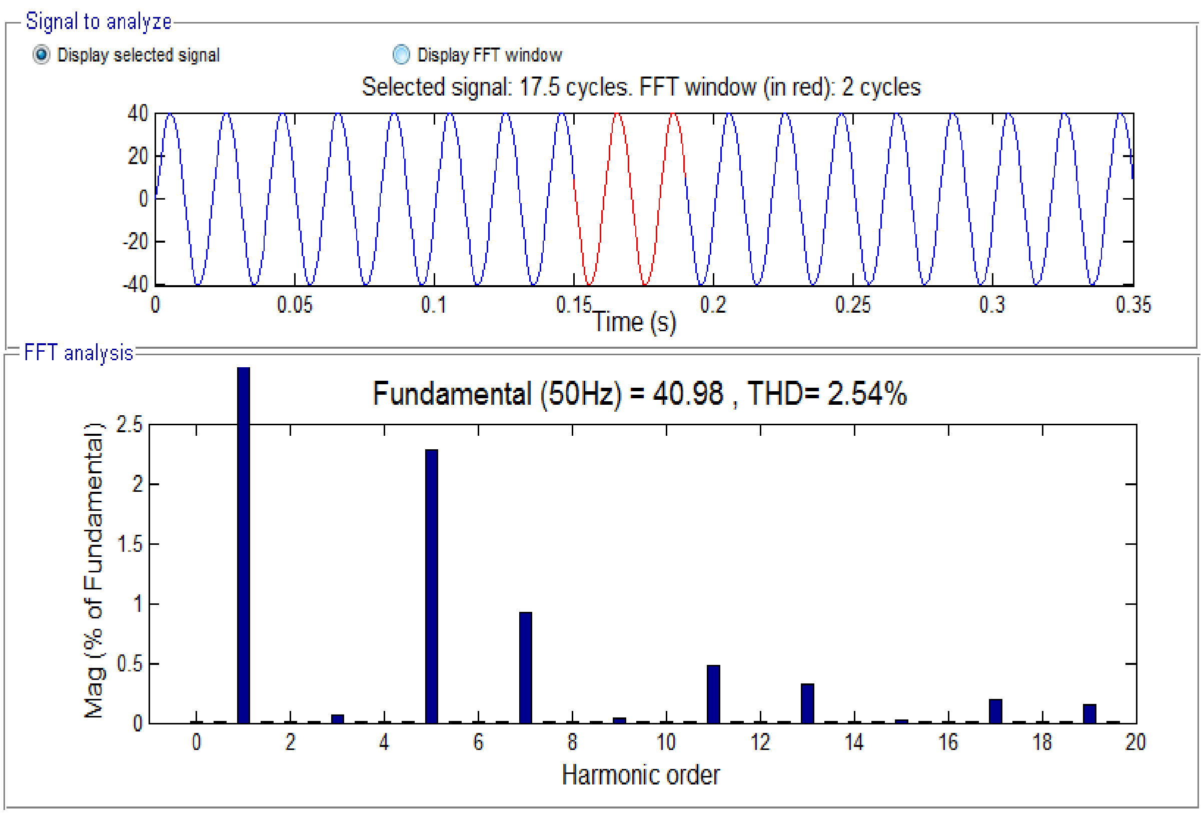

Fig. 15 Current THD of System with UPQC

Table 2 THD Comparison (UPQC Model)

Total Harmonic Distortion	Without UPQC	With UPQC
Voltage	13.51 %	3.82 %
Current	26.18 %	2.54 %

Unified power quality conditioner is implemented on 440 V distribution network in MATLAB. Performance of the system with & without UPQC has been analyzed and simulated results of voltages and currents are displayed in fig. 6.16-6.19. To compare the performance of the system with and without connecting UPQC, THD in voltage and current for both cases have been measured and displayed in fig. 6.20-6.23. From the above analysis, it is found that implemented UPQC model is capable to reduce voltage harmonics of system up to 71.72 % and current harmonics of system up to 90.29 %.

XI. CONCLUSION

In this dissertation work power quality issues were discussed and UPQC model is proposed to mitigate voltage and current harmonics. The proposed UPQC model is simulated with five bus transmission network and it is found that it is possible to mitigate distortion in voltage and current waveforms of system. Hence Total Harmonic Distortions are diminished with the help of UPQC model and system performance can be enhances.

REFERENCES

[1] S. S. Wamane, J. R. Baviskar, S. R. Wagh and Shantanu Kumar, "Performance - based Comparison of UPQC Compensating Signal Generation Algorithms under Distorted Supply and Non linear Load Conditions.", IEEE ©2013.

[2] Hideaki Fujita, Hirofumi Akagi, "The Unified Power Quality Conditioner: The Integration of Series and Shunt Active Filters", IEEE Transactions on Power Electronics, Vol. 13, No. 2, March 1998.

[3] G-Myoung Lee, Dong-Choon Lee and Jul-Ki Seok, "Control of Series Active Power Filters Compensating for Source Voltage Unbalance And Current Harmonics", IEEE Transactions on Industrial Electronics, Vol. 51, No. 1, February 2004.

[4] Hamid Reza Mohammadi, Ali Yazdian Varjani and Hossein Mokhtari, "Multiconverter Unified Power-Quality Conditioning System: MC-UPQC", IEEE Transactions on Power Delivery, Vol. 24, No. 3, July 2009.

[5] V. Khadkikar, A. Chandra, A. O. Barry and T. D. Nguyen, "Conceptual Study of Unified Power Quality Conditioner (UPQC)", IEEE ISIE 2006, Montreal, Quebec, Canada, July 9-12, 2006

[6] Hirofumi Akagi, Yoshihira Kanazawa and Akira Nabae, "Instantaneous Reactive Power Compensators Comprising Switching Devices Without Energy Storage Components", IEEE Transactions on Industry Applications, Vol. Ia-20, No. 3, May/June 1984.

[7] P.Vasudeva Naidu, B.Basavaraja, "Design of A SRF Based MC UPQC Used for Load Voltage Control in Parallel Distribution Systems", ©2012 IEEE.

[8] A. Jeraldine Viji, Dr. M. Sudhakaran, "Generalized UPQC System with An Improved Control Method Under Distorted and Unbalanced Load Conditions", International Conference on Computing, Electronics and Electrical Technologies [ICCEET], 2012.

[9] Moleykutty George, Kartik Prasad Basu, "Modeling and Control of Three- Phase Shunt Active Power Filter", American Journal of Applied Sciences, ISSN 1546-923, 2008.

[10] A. Nasiri, A. Emadi, "Different Topologies for Single Phase Unified Power Quality Conditioners", IEEE © 2003.

[11] B. Rajani, Dr. P. Sangameswara Raju and K. Rama Raju, "Performance Analysis of Multi Converter Unified Power Quality Conditioner for Power Quality Improvement", International Journal of Engineering Research and Applications (IJERA), Vol. 2, Issue 4, ISSN: 2248-9622, July-August 2012.