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Study of Power Quality by using Different Power Circuit Topology & Control Scheme in UPQC

Monali Pratap Kolekar[1], Prof. K Chandra Reddy[2]

Assistant Professor, Dept. of EE, Matsyodari College of Engineering, Jalna, Maharashtra, India[2]

PG Student [EE], Dept. of EE, Matsyodari College of Engineering, Jalna, Maharashtra, India[1]

ABSTRACT: In little extra than ten years, electricity power strength has grown from obscurity to a first-rate trouble. Power quality is some of the principal matters this is emphasized and is taken into consideration by means of utilities if you want to meet the demands of their patron. At each passing day this problem has becoming greater severe and at the equal time the person's demand on power high-quality additionally receives more important. Thus it is essential to establish a power quality monitoring system to detect power quality disturbance. Several studies research regarding the power great have been carried out earlier than and their pursuits often targeting the collection of raw facts for a in addition evaluation, so the impacts of diverse disturbances can be investigated. Exceptional manage schemes had been recommended for UPQC. Additionally a method is proven for figuring out the maximum touchy bus and the sensitive load. UPQC is established among the touchy bus and the load with 3 exceptional manipulates schemes and outcomes are proven for specific types of fault at one-of-a-kind-different locations. Also a comparison is proven among all the manage schemes.

KEYWORDS: UPQC, Voltage Sag, Voltage Swell, power best. Hysteresis control, Unit vector template generation method, PWM method.

I.INTRODUCTION

Power quality is defined as "the concept of powering and grounding electronic equipment in a manner that is suitable to the operation of that equipment and compatible with the premise wiring system and other connected equipment", in Institute of Electrical and Electronics Engineers (IEEE) Standard 1159-1995 (IEEE Std 519, 1995) . International Electro-technical Commission (IEC) defined power quality as set of parameters defining the properties of power quality as delivered to the user in normal operating conditions in terms of continuity of supply and characteristics of voltage (frequency, magnitude, waveform and symmetry) . In recent years, demand of Distributed Generation (DG) is increased to minimize the gap between the supply and load demand. This introduces some voltage and current disturbance and harmonics due to the generator types and the interfacing power electronics converters used. Therefore, quality of power supply has become an important issue with the increasing demand of DG systems either connected to the grid through grid-tie inverters or work in isolated (micro-grid) mode. From last two decades the use of automation is increased in industries. Various drives are employed for speed-torque control of motors. These drives use converter inverter set. Also various robotic instruments are used for precious and efficient work. In this way, the use of artificial intelligence is increased. These techniques exhibit the advantages of reduced losses, weight and maintenance costs. To employ such modern technologies, large numbers of power electronic switches are used. Such as Diodes, Thrusters, IGBTs etc. are used for building of converters. Large number of transistors are used in robots, computers etc. These switches inherently possess non-linear characteristics. So, these loads behave as non-linear loads taking non-sinusoidal current. In turn they introduce large number of harmonics in supply mains. Also, there are some processes like arc furnaces induces 5th & 7th harmonic in mains voltage Ideally power system network must be electrically clean, harmonics free, balanced, pure sinusoidal with constant amplitude and unity power factor, Obviously.

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II.OBJECTIVES

The main objectives of this research are outlined as follows:

1) To describe various Power Quality (PQ) standards set by different institutions, introduction to commonly occurred PQ problems and its negative impact on utility system as well as on customer appliances.
2) To present literature survey of Shunt APF, Series APF and UPQC system with their power circuit topologies and control strategies.
3) To design various components of UPQC system using scientific approach with the help of standard mathematical formulae.
4) Improving performance of UPQC system by employing latest techniques for regulation of DC-link capacitor voltage.
5) To develop simulation model of UPQC system, to discuss about simulation results of UPQC system with different control strategies, examining whether they meet international standards.

III.SHUNT APF

From last two decades the use of automation is increased in industries. Various drives are employed for speed-torque control of motors. These drives use converter inverter set. Also various robotic instruments are used for precious and efficient work. In this way, the use of artificial intelligence is increased. These techniques exhibit the advantages of reduced losses, weight and maintenance costs. To employ such modern technologies, large numbers of power electronic switches are used. Such as diodes, thrusters, IGBTs etc. are used for building of converters. Large number of transistors are used in robots, computers etc. These switches inherently possess non-linear characteristics. So, these loads behave as non-linear loads taking non-sinusoidal current. In turn they introduce large number of harmonics in supply mains. In ideal conditions, the source current must be sinusoidal, harmonic less. In order ensure this; Shunt APF is employed to compensate current harmonics in supply,

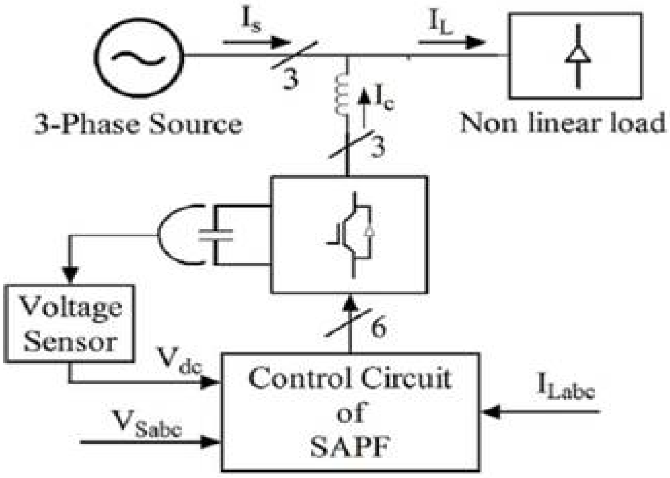

Fig.1 General schematic shunt APF

1) Based on type of supply system
   - Single Phase (Two wires)
   - Three Phase Three Wire
   - Three Phase Four Wire
2) Based on Inverter Configuration used
   - Two Level Inverter (Used for Low & Medium Power Applications)
   - Multi – Level Inverter (Used for Medium & High Power Applications)
3) Based on Problem Specification
   - For Balanced Load (Three Phase Three Wire is used)
   - For Unbalanced Load (Three Phase Four Wire is used)

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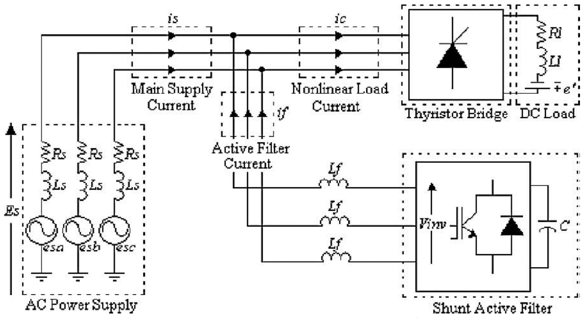
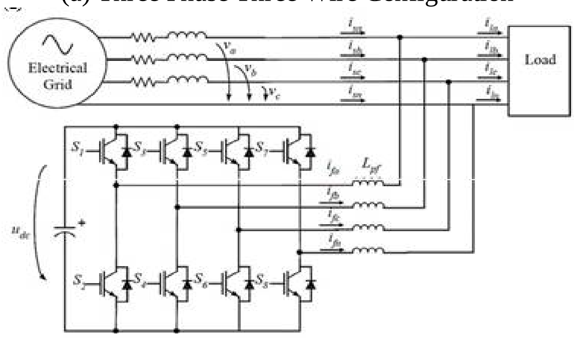
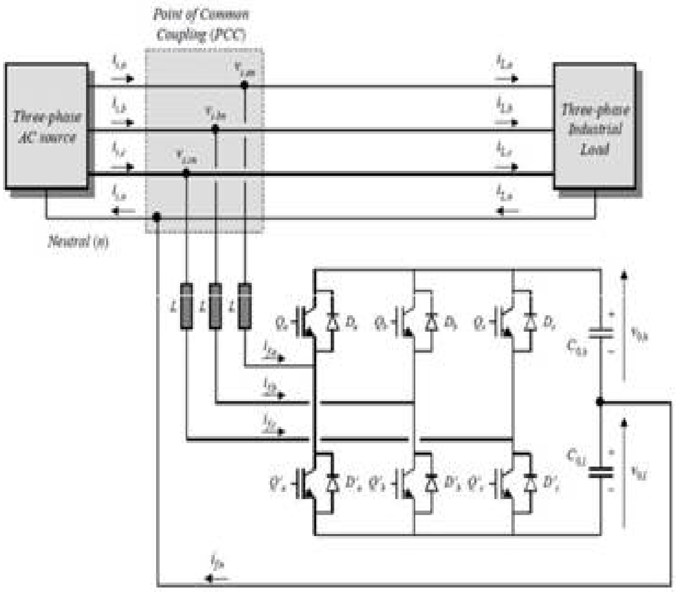
3.1 Power Circuit Topologies of Shunt APF



(a) Three Phase Three Wire Configuration



(b) Three Phase Four Wire with extra Leg



(c) Three Phase Four Wire with split capacitor

The two level active filters have limitations in medium and high voltage application due to semiconductor's reverse voltage rating constraint, Use of transformer for high voltage applications, with active power filter requires high VA rating of transformer which results in high magnitude of current on low voltage side and causes more losses. The system becomes bulky and costly. Multilevel inverters are effective in high voltage applications as these provide high output voltages with same voltage rating of individual device and maintaining low individual device switching frequency. The use of multilevel inverter also eliminates the need of transformer to feed the power to HV system. Also

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they can operate on low switching frequency. So, they offer low switching losses. The mainly used multilevel topologies are Diode-clamped, Cascade and Flying capacitor type.

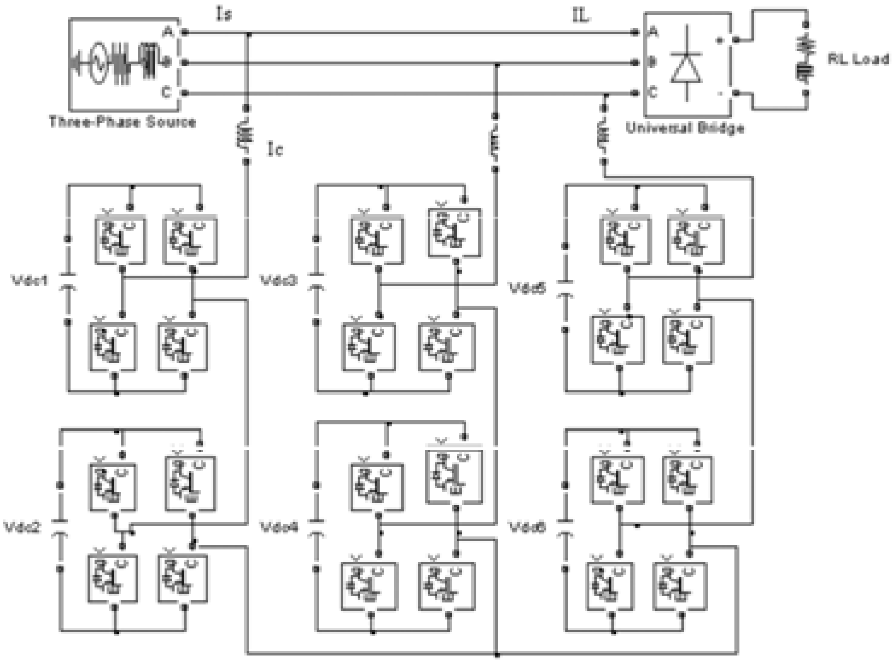

Fig.2 Cascaded Multilevel Shunt APF

IV.SERIES APF

The loads which causes current harmonics problem, may also led to voltage distortion problem. Also, there are some loads like Arc Furnaces introduces 5th and 7th order harmonics in mains voltage. The Series APF is used for mitigation of voltage distortions. The Series APF can be build same as that of Shunt APF; but differs in control algorithm and the work they does. Series APF control algorithm is same as that of Dynamic Voltage Restorer (DVR). But DVR is used at transmission level, where the main voltage problems are sag, swell etc. Whereas the problem is quite different, when we move towards distribution level. Here is the problem is voltage distortion due to harmonics, which is compensated by using Series APF.

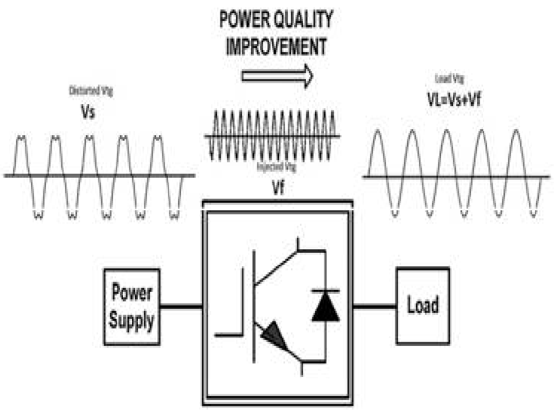

Fig.3 General representation of series APF

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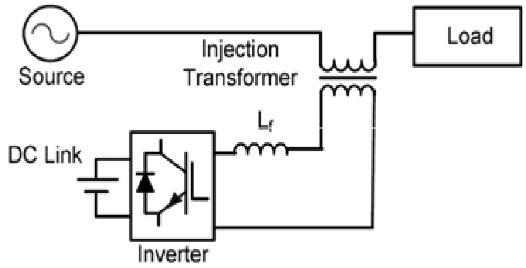
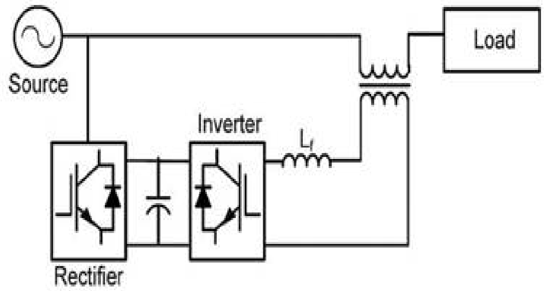
4.1 Power Circuit Topologies of Series APF

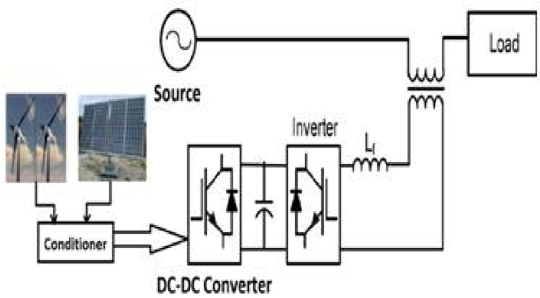
Power circuit of Series APF mainly consists of inverter part, series injection transformers, Energy storage element (capacitor) or may be different DC supply (Battery). In case of Series APF, it is not possible to charge capacitor through the same inverter, which can be easily done in Shunt APF. The reason behind this is that, in order to charge capacitor, we have to calculate loss component of charging capacitor and we have to give it to the capacitor.



a) Series APF with Auxiliary Supply



b) Series APF with Capacitor Charging from Grid itself



c) Series APF with Auxiliary Supply realized using Fig.4 Renewable Energy Sources.

4.2Control Circuit

The control algorithm of Series APF consists of two parts.

- To control the circuitry which is used to supply energy to Series APF,
- To control the operation of Inverter part of Series APF.

V. UPQC

Shunt APF tackles current distortion problems; while Series APF tackles voltage distortion problems only. Also there is problem with Series APF capacitor charging, as it requires extra circuitry. Again, at Distribution level both voltage and current distortions may occur at a time. It is inappropriate to install both these devises, as cost of overall system will increase, it will require extra circuitry, may occupy large space. So, we require a system which will tackle all power quality problems at a time with minimum cost, circuitry and space. An UPQC system can handle voltage and current harmonic problems, simultaneously. It is nothing but the combination of Shunt and Series This system allows charging

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of Capacitor through Shunt APF part of UPQC. Therefore same capacitor is used as Voltage source for Series APF also. So, UPQC system requires only one capacitor, does not require extra circuitry to charge it, requires less space, still able to mitigate all power quality problems.

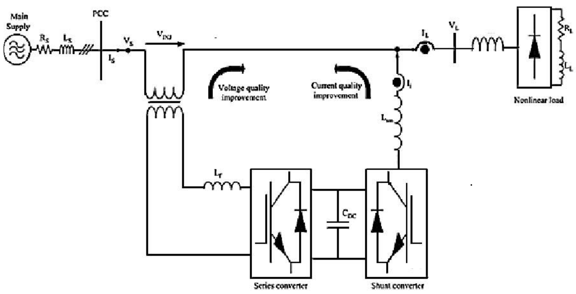
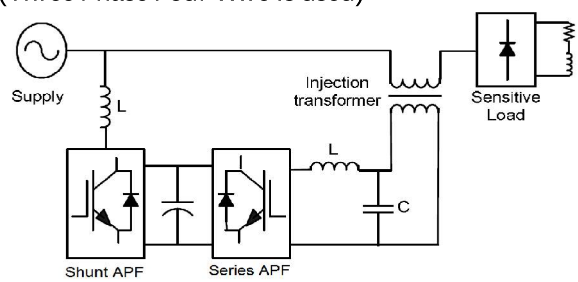


Fig.5 General Schematic of UPQC system

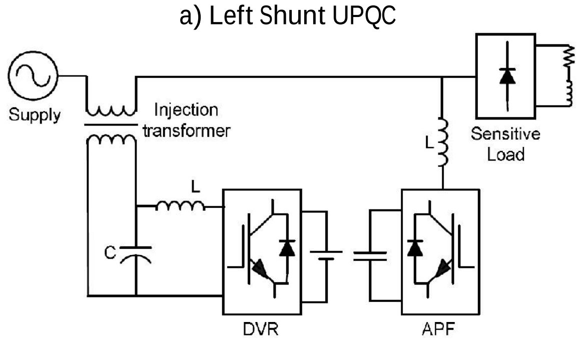
5.1 Power Circuit Topologies of UPQC

Similar to Shunt APF, UPQC system can also be classified according to; 1) Type of supply mains 2) Inverter Configuration 3) Problem Specification.

1) Based on type of supply system
   - Single Phase (Two wire)
   - Three Phase Three Wire
   - Three Phase Four Wire
2) Based on Inverter Configuration used
   - Two Level Inverter (Used for Low & Medium Power Applications)
   - Multi – Level Inverter (Used for Medium & High Power Applications)
3) Based on Problem Specification
   - For Balanced Load (Three Phase Three Wire is used)
   - For Unbalanced Load (Three Phase Four Wire is used)



a) Left Shunt UPQC



b) Open UPQC

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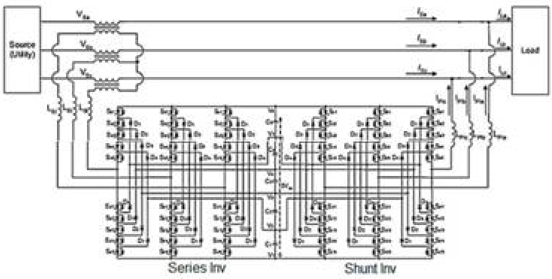

c) Diode Clamped Multilevel UPQC

VI.SIMULATIONS RESULTS

A UPQC simulation model (Fig.4) has been created in MATLAB/Simulink so as to investigate UPQC circuit waveforms, the dynamic and steady-state performance, and voltage and current ratings. The following typical case studies have been simulated and the results are presented.

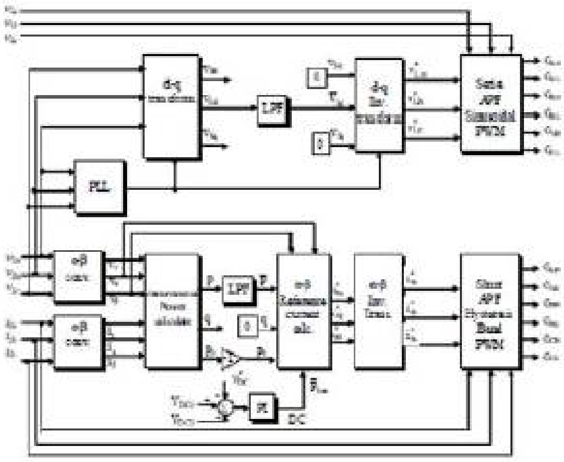

Fig.6 Series APF reference voltage and shunt APF reference current signal generation block diagram

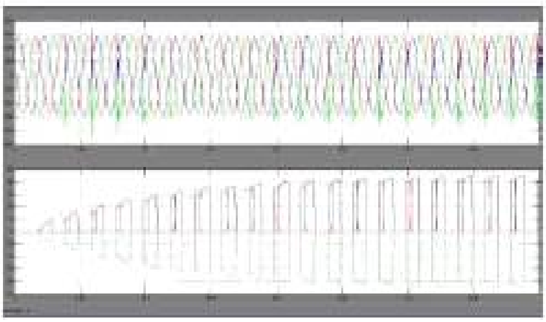

Fig.7 Steady state source voltage and load current waveforms (without UPQC) THD of source voltage: 25.9%, THD of load current: 63%

1) Short duration three phase fault conditions.
2) Long duration three phase fault conditions.
3) Dynamic load and three phase fault conditions.
4) Harmonic compensation
5) DC link voltage regulation for the above conditions is also verified.

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DC link voltage dips slightly during fault condition but is Maintained constant by UPQC.. Results show that it gives good steady state and transient performance. The proposed control scheme is feasible and simple to implement although further work is needed to optimize the parameters of the UPQC.

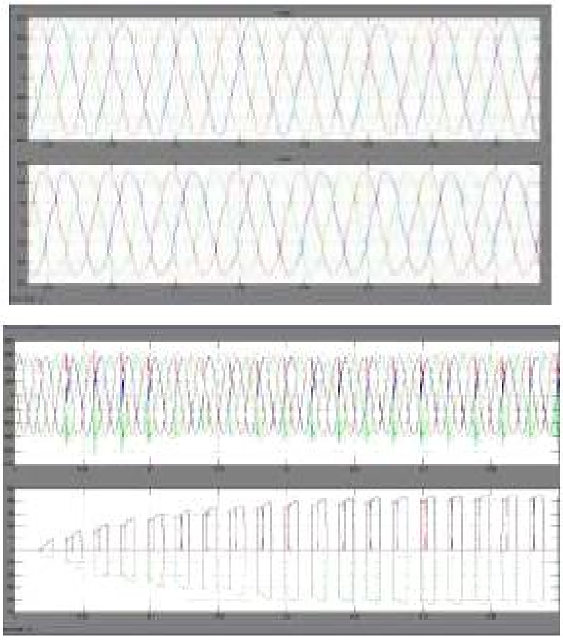

Fig.8 Steady state source voltage and load current waveforms (with UPQC) THD ofsource voltage: 0.98%;THD of load current:1.03%

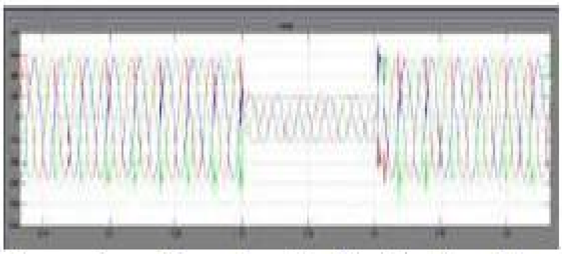

Fig.9 Source voltage when a three phase fault is introduced from 0.3 to 0.4 seconds. (Without UPQC) (THD: 27%)

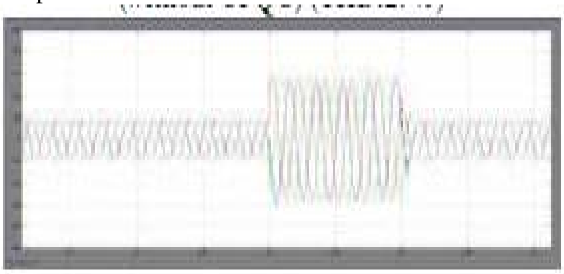

Fig.10 compensating voltage injected by series active filter

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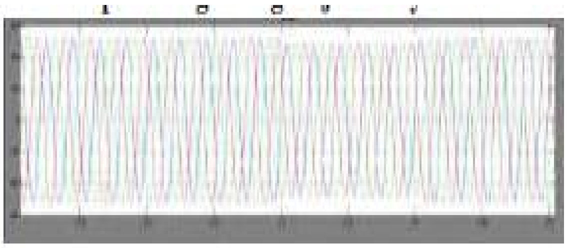

Fig.11 Source voltage when a three phase fault is introduced from 0.3 to 0.4 seconds. (With UPQC) (THD: 0.50%)

VII.CONCLUSIONS

This paper describes a new control strategy used in the UPQC system, which mainly compensate reactive power and voltage and current harmonics in the load under non-ideal mains voltage and unbalanced load current conditions. The proposed control strategy use only loads and mains voltage measurements for series APF based on the synchronous reference frame theory. The instantaneous reactive power theory is used for shunt APF control algorithm by measuring mains voltage and currents. The conventional methods require measurements of the load, source and filter voltages and currents.

The simulation results show that, when unbalanced and nonlinear load current or unbalanced and distorted mains voltage conditions, the above control algorithms eliminate the impact of distortion and unbalance of load current on the power line, making the power factor unity. Meanwhile, the series APF isolates the loads voltages and source voltage, the shunt APF provides three-phase balanced and rated currents for the loads. The experimental results obtained from a laboratory model of 10 kVA, along with a theoretical analysis, are shown to verify the viability and effectiveness of the proposed UPQC control method.

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