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A Novel Fast Action PV based EUPQC for Performance Improvement

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***ABSTRACT*:** DFACTS introduced an effective compensating device named as Unified Power Quality Conditioner (UPQC) to improve the power quality in the distribution network. A new configured UPQC has introduced in the distribution network with the PV cell for improving the power quality at the supply main. This work described the unified power quality conditioner principles and the power restoration for balanced or unbalanced sag/swell in a distribution system. This method proposes a new configuration of UPQC for compensating sag conditions for three phase system that consists of a DC/DC converter supplied by a PV Cell at the DC link. This concept presents the operation of UPQC as a universe active power conditioning device to mitigate both current as well as voltage distortions at a distribution end of the power system network. Series compensator which is meant for voltage restoration controlled by PI controller. Shunt compensator's operation is controlled by extracting d axis q axis current from load current and the DC link voltage is maintained through a fuzzy logic controller. The performance of UPQC mainly depends upon how quickly and accurately compensation signals are derived. Thus the combination of weak grids, wind power fluctuation and system load changes produces disturbances in the PCC voltage, worsening the power quality and stability. In this proposed concept, fuzzy controller with reference signal generation method is designed for UPQC. This is used to compensate current and voltage quality problems of sensitive loads. The results are analysed and presented using MATLAB/SIMULINK SOFTWARE

KEYWORDS*:* UPQC; DFACT; FUZZY; EUPQC*;*

I. Introduction

Electrical energy is the most efficient and popular form of energy and the modern society is heavily dependent on the electric supply. The life cannot be imagined without the supply of electricity. At the same time the quality of the electric power supplied is also very important for the efficient functioning of the end user equipment. Electrical energy is the most efficient and popular form of energy and the modern society is heavily dependent on the electric supply. The life cannot be imagined without the supply of electricity. At the same time the quality of the electric power supplied is also very important for the efficient functioning of the end user equipment.

The term power quality became most prominent in the power sector and both the electric power supply company and the end users are concerned about it [1]. The quality of power delivered to the consumers depends on the voltage and frequency ranges of the power. If there is any deviation in the voltage and frequency of the electric power delivered from that of the standard values then the quality of power delivered is affected.

Now-a-days with the advancement in technology there is a drastic improvement in the semi-conductor devices. With this development and advantages, the semi-conductor devices got a permanent place in the power sector helping to ease the control of overall system. Moreover, most of the loads are also semi-conductor based equipment. But the semi-conductor devices are non-linear in nature and draws non-linear current from the source. And also the semi-conductor devices are involved in power conversion, which is either AC to DC or from DC to AC. This power conversion contains lot of switching operations which may introduce discontinuity in the current. Due to this discontinuity and non-linearity, harmonics are present which affect the quality of power delivered to the end user. In order to maintain the quality of power delivered, the harmonics should be filtered out. Now-a-days with the advancement in technology there is a drastic improvement in the semi-conductor devices.

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II. POWER QUALITY ASPECTS

Power quality is certainly a major concern in the present era; it becomes of especially important with the introduction sophisticated devices, whose performance is very sensitive to the quality of power supply. Modern industrial processes are based on a large amount of electronic devices such as programmable logic controllers and adjustable speed drives. Electronic devices are very sensitive to disturbances and thus industrial loads become less tolerant to power quality problems.

Power Quality (PQ) has become an important issue since many loads at various distribution ends like adjustable speed drives, process industries, printers, domestic utilities; computers, microprocessor based equipments etc. have become intolerant to voltage fluctuations, harmonic content and interruptions.

Power Quality (PQ) mainly deals with issues like maintaining a fixed voltage at the Point of Common Coupling (PCC) for various distribution voltage levels irrespective of voltage fluctuations, maintaining near unity power factor power drawn from the supply, blocking of voltage and current unbalance from passing upwards from various distribution levels, reduction of voltage and current harmonics in the system and suppression of excessive supply neutral current. Recently, the importance of power quality issues has increased due to various reasons.

First of all, there have been changes in the nature of electrical loads. On one hand, the characteristics of load have become more complex due to the increased use of power electronic equipment, which results in a deviation of voltage and current from its sinusoidal waveform. On another hand, equipments have become more sensitive to power quality due to its electronic nature. Deregulation of the electrical power market is a second factor that has increased the importance of power quality. Deregulation has divided what was a single utility into three: supplier, transmitter and distributor. It is important to evaluate power quality level and identify the source of faults that origin electrical disturbances in electrical power systems, which determines the responsibility of a bad quality of power. In order to evaluate and identify the disturbances and its origin, power quality monitoring is the tool that utilities and customers use.

III. ENERGY- STORAGE UPQC (EUPQC)

The unified power quality conditioner (UPQC) is a custom power device, which mitigates voltage and current-related PQ issues in the power distribution systems. In this chapter, a UPQC topology for applications with non-stiff source is proposed. The proposed topology enables UPQC to have a reduced dc-link voltage without compromising its compensation capability. This proposed topology also helps to match the dc-link voltage requirement of the shunt and series active filters of the UPQC. The topology uses a capacitor in series with the interfacing inductor of the shunt active filter, and the system neutral is connected to the negative terminal of the dc-link voltage to avoid the requirement of the fourth leg in the voltage source inverter (VSI) of the shunt active filter. The average switching frequency of the switches in the VSI also reduces, consequently the switching losses in the inverters reduce. The reported topologies of 3P-4W UPQC [7-13] use active compensation of source neutral current, while the uses of passive elements for the mitigation of source neutral current are advantageous over the active compensation due to ruggedness and less complexity of control.

A. SYSTEM DESCRIPTION:

The system under consideration for three-phase, four wire distribution system is shown in Fig: 1. The UPQC is connected before the load to make the source and the load voltage free from any distortions. At the same time, the reactive current drawn from the source should be such that the currents at source side would be in phase with utility voltages. Provision is made to realize voltage harmonics in the source voltage by switching on/off the three- phase diode bridge rectifier. The UPQC, carried out by using two VSIs, is shown in Fig: 2: one VSI acts as the shunt APF and the other as the series APF. The shunt APF is realized using a three-phase, four-leg VSI, and the series APF is carried out using a three-phase, three-leg VSI. Both APFs share a common dc link between them.

The four-leg, VSI based shunt active filter is capable of suppressing the harmonics in the source currents, negative sequence of the source current, load balancing, and power-factor correction. The implemented control algorithm consists

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mainly of the computation of the three-phase reference voltages of load (V*la, V*lb, V*lc) and the reference currents for the source current (i*sa, i*sb, i*sc).

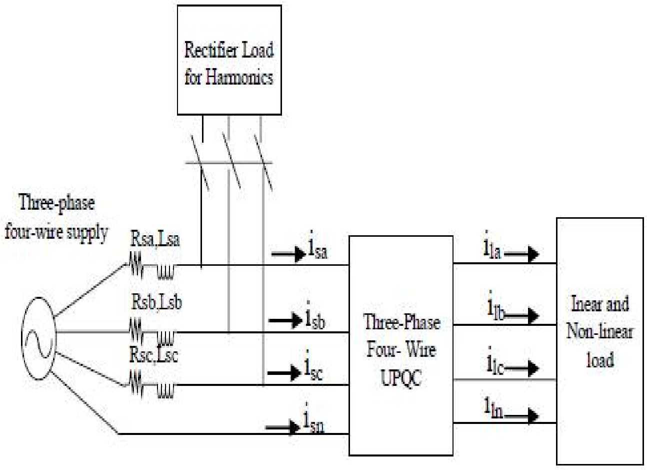

Fig: 1. The distribution system with UPQC

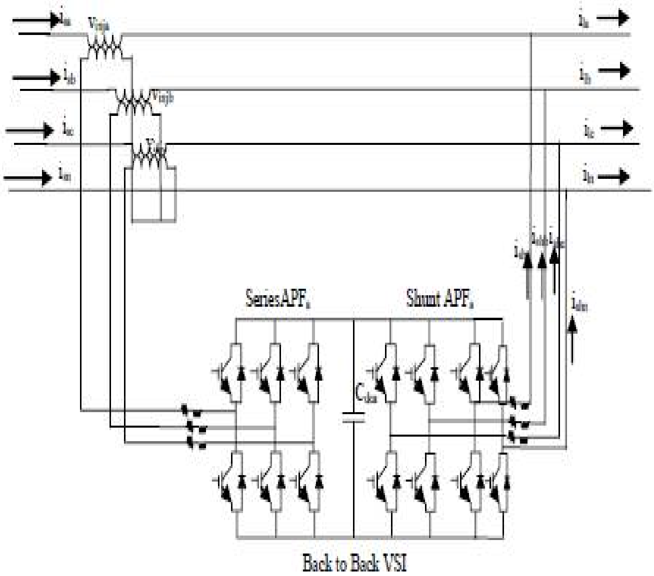

Fig: 2. UPQC block diagram

The voltage at the source side before UPQC, load voltage at the load, voltage injected by the series APF, and dc link voltage between two inverters are represented by vs, vL, vinj, and Vdc, respectively. The current on the source side, current drawn by the loads, neutral current on the source side, load neutral current, and current injected by the shunt APF are represented by is, il, isn, iln, and ish, respectively.

B. ***STURUCTURE OF EUPQC.***

As shown in Fig: 3, the main circuit system structure of EUPQC includes series converter, parallel converter, booster and discharge unit which consisting of super capacitor energy storage and DC/DC converter, outputting power transformer TsA~TsCof series converter, output filters Ls and Cs of series converter and inductance Lp of parallel converter [5]. The electric interfaces A1, B1, C1, and N1 connect distribution network source and the A2, B2, C2, and N2 connect various loads. Two sets of three-phase four-leg converter respectively compose the series and parallel converters of the EUPQC. The series converter output enters into distribution network via LC filter and transformer in series.

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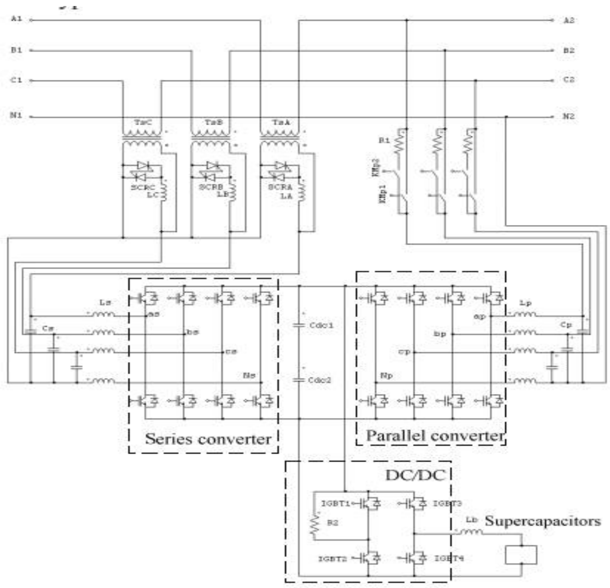

Fig: 3 Main structure of EUPQC

IV. Simulation Results

The simulation block diagram is shown below

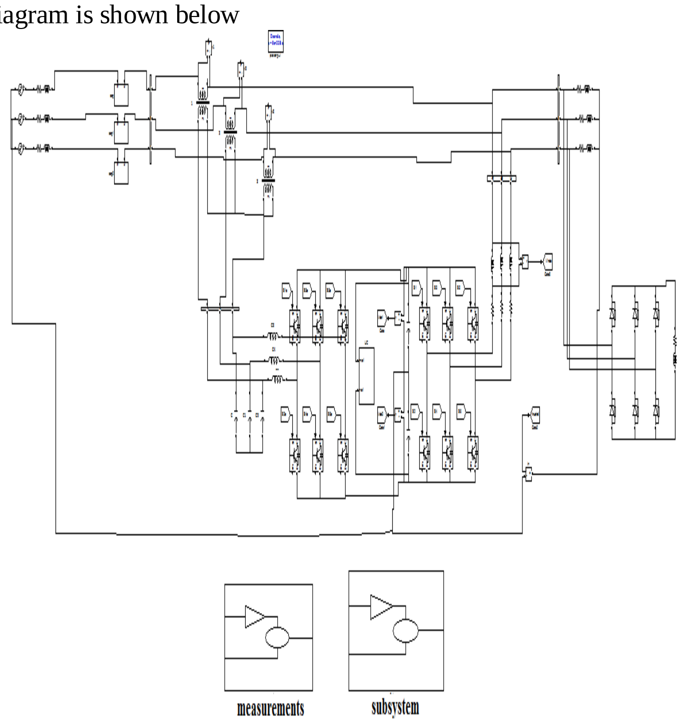

Fig: 4 Simulink Block diagram

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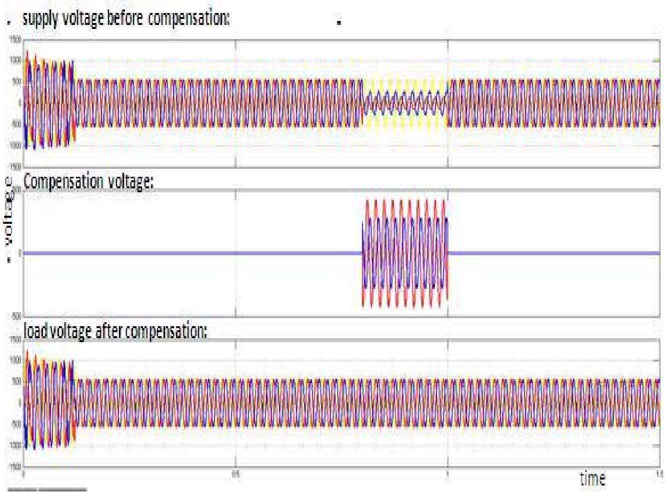

Fig: 5 voltage compensation under sag condition

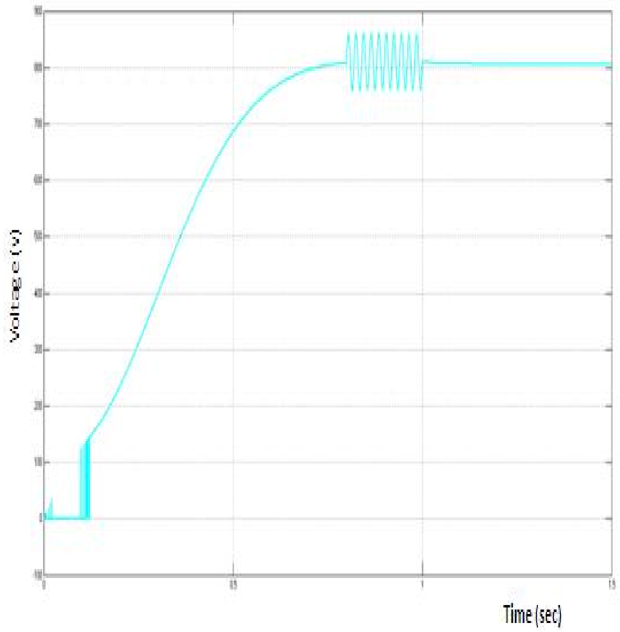

Fig 6 DC bus voltage

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A. TOTAL HARMONIC DISTORTION OF SOURCE CURRENT WITH PI CONTROLLER:

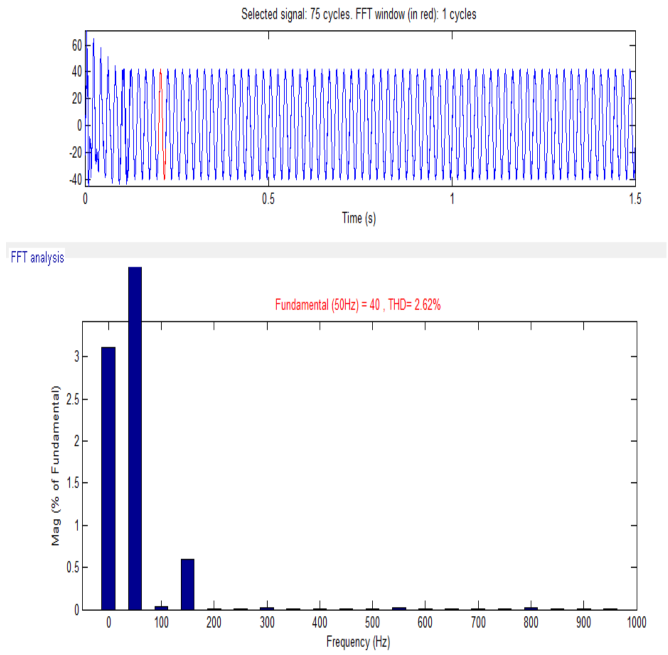

Fig 7 Total Harmonic Distortion of source current with PI controller.

B. TOTAL HARMONIC DISTORTION OF SOURCE CURRENT WITH FUZZY CONTROLLER:

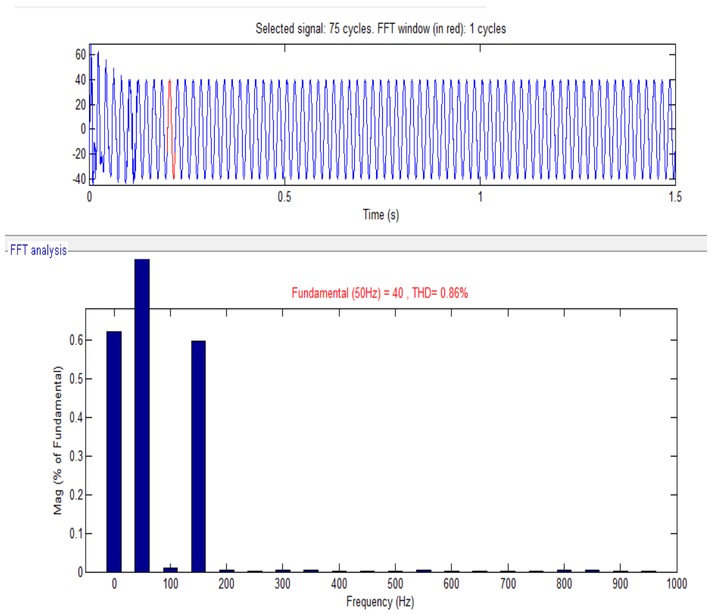

Fig 8 Total Harmonic Distortion of source current with Fuzzy controller

Figure 7 and 8 shows the total harmonic distortion in source current using PI controller and Fuzzy logic controller in the DC/DC converter in the EUPQC. We can observe that there is a change in the THD value under both converter

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control strategies using PI and Fuzzy in DC/DC converter control to maintain the DC bus voltage constant under nonlinear load conditions. The content of harmonics in the source current is reduced while using Fuzzy control strategy in DC/DC converter control i.e percentage of THD value reduced from 2.62% to 0.86%. Thus by using the Fuzzy control strategy in place of PI controller in the DC/DC converter the response of the system can be increased under non linear conditions.

V. CONCLUSION

This paper proposes a new configuration of UPQC that consists of the DC/DC converter and super capacitor. The proposed EUPQC compensates the voltage sag and swell, voltage interruption, voltage unbalance, reactive power and harmonic current. By using compensating control methods the series, shunt and DC/DC converters compensates the voltage and current quality problems in the distribution network. We can observe the reduction in total harmonic distortion of source current by using a fuzzy logic control technique in the DC/DC converter control for maintain the DC bus voltage constant under nonlinear load conditions. In all operating simulation results shows effective and accurate power quality control using fuzzy logic control. The THD of source has been observed an IEEE 519-1992 standard limit of 5%. The designed multi converter UPQC is tested using MATLAB/simulink with different load conditions. The proposed configuration of UPQC can able to compensate voltage sag/swell, interruption and current harmonics, load balancing etc.

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