A STUDY PAPER BASED ON COMPENSATION OF VOLTAGE DISTORTION AND MINIMIZATION OF HARMONIC USING UPQC

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ABSTRACT

This paper presents the comprehensive reviews for compensation of voltage distortion and minimization of harmonics in the power supply which is caused by the non-linear characteristic based loads. This paper present a broad overview on different possible topology of UPQC for single-phase and three-phase networks and recent development in the fields. It is observed that many researchers have used different names for the UPQC based on the application and topology. Hence keeping in view of the above concern, research has been carried out to compensation of voltage distortion and minimization of harmonics. The authors strongly believe that the literature survey will be very much useful to the researchers for finding out the relevant references in the field of power quality problems mitigated by UPQC.

Keywords: Distribution Static Compensation (D-STATCOM), Harmonic Compensation, Hybrid Filters, Unified Power Quality Conditioner (UPQC), Voltage Distortion Compensation

I. INTRODUCTION

Power quality issue are of great concern in transmission and distribution system nowadays due to the sensitive nature of load. In power system poor power quality due to different factors, such as voltage sag, voltage swell, poor power factor, and unaccepted level of harmonics in voltage and current waveforms. In distribution system at the load end are facing poor power quality. The reason behind this is the increase of electronics devices which are used by the residences as well as industry. For working properly these devices need high quality energy. The harmonics presence in the system results in several effects such as increased heating losses in motors, transformers and lines. In this scenario, provide quality power to the consumers is difficult for power utility companies. To compensate these identify power quality problems efforts are going on in the name of passive filters, active filters and hybrid filters. Passive filters has the limitations such as, fixed compensation, resonance with the source impedance of filter parameters have forced the use of active and hybrid filters. For enhancing the quality of the power supply and reliability a new technology custom power devices are emerged. Custom power devices include DVR, STATECOM and UCPC/UPQC. The UPQC Unified Power Quality Conditioner is one of the custom power device, which can compensate both voltage and current related problems. The UPQC is one of the APF family members where series and shunt functionalities are integrated together to achieve the control of voltage and current related problems. The shunt APF is usually connected across the loads to compensate for all current related problems, whereas the series APF is connected in a series with the line through series transformer to compensate all voltage related problems.

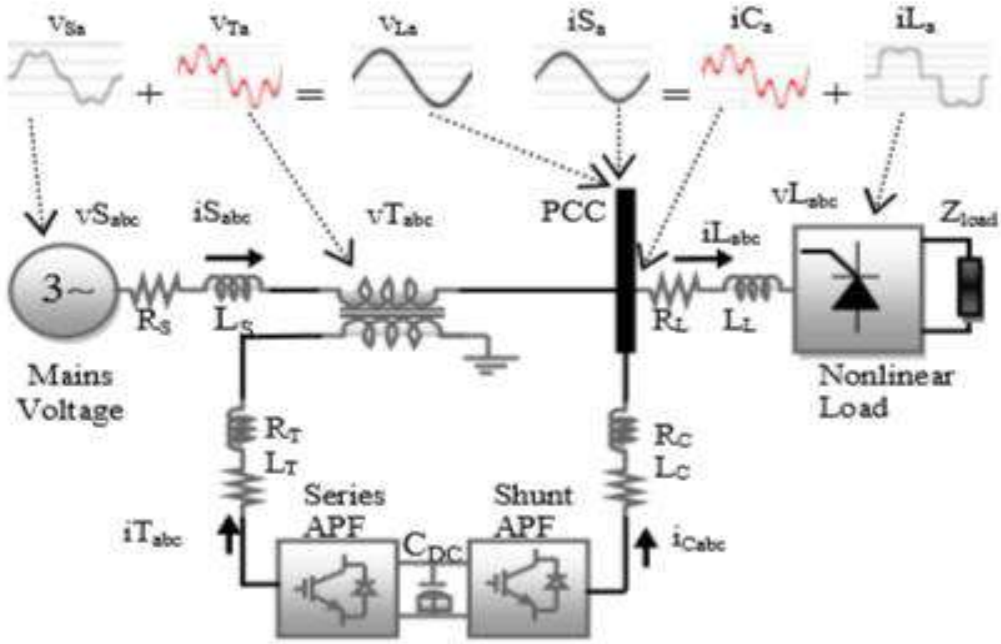

Fig. 1 Unified Power Flow Controller Configuration

II. LITERATURE REVIEWS

In **2009** Khadkikar Stated that due to numerous advantages offered by power electronics based equipments are a Major key component of today's modern power processing, at the transmission as well as the distribution level. Some devices, equipments, nonlinear load including saturated transformers, arc furnaces and semiconductor switches draw non-sinusoidal currents from the utility. Therefore a typical power distribution system has to deal with harmonics and reactive power support.

In **1998** Fujtha Stated that for low impedance path for current harmonics we used passive filters, so that they not flow in the supply and flow in the filter. These filters are applicable only to particular harmonics, for triple-N harmonics isolating transformer is useful and passive filters only for their designed harmonic frequency. The harmonics current is less predictable in some installations.

In **1999** Singh Stated that Improving the power factor and eliminating harmonic distortion we used power factor correction techniques that include both passive and active filters. To reduce phase shift and harmonics uses inductors, transformers, capacitors and other passive component in passive approach. The passive approach is heavier and less compact than the active approach, which is finding greater favour due to new technical developments in circuitry, superior performance and reduced components costs. Power factor correction techniques must be applied to each load or power supply in the system.

In **2000** Joao Afonso stated that for controlling current harmonics in supply networks at low to medium voltage distribution level or for reactive power and/or voltage control at high level, active Power Filters have become a solution,

In **2004** Das stated that, Frequency domain approaches are suitable for both single and three-phase systems. The Frequency domain algorithms are sine multiplication techniques, conventional Fourier and fast Fourier Transform (FFT) algorithms and modified Fourier series techniques.

In **2004** Chen stated that, APF's controls methods in the time domain are based on instantaneous derivation of compensating commands in the form of either voltage or current signals from distorted and harmonic polluted voltage or current signal.

In **2002** Ghosh stated that for Power (<100 KVA), medium Power (100KVA- 10MVA), and High Power (>10 MVA) application, APFs are used. In Single phase and three Phase systems APFs can be applied for low power applications. For Single Phase systems, APFs generally mitigate the current harmonics. For three- Phase systems, APFs generally provide acceptable solutions for unbalanced load current and mitigate the current harmonics. For medium and high power applications, the main aim is to eliminate or reduce the current harmonics.

In **2003** Karimi stated that reactive power compensation using active filters at the high voltage distribution level is not generally regarded as viable because of economic consideration. For high power applications, the harmonic pollution in high power ranges is not such a major problem as in lower power systems. Active filters applications in high power systems are the installation of parallel combination of several active filters because the control and co-ordination requirements of these filters are complicated.

In **2005** Jindal stated that for some applications the combinations of several types of filter can achieve greater benefits. The examined combinations are combination of both parallel and series active filters, combination of series active and parallel passive filters, combination of parallel active and passive filters and active filter in series with parallel filters. Seven-level APF configuration is also examined in this paper.

In **1995** Gunther stated that in medium and large capacity applications multilevel three-leg center-split VSIs are more preferable due to lower initial cost and fewer switching devices that need to be controlled. The multilevel series stacked converter topology, which allows standard three phase inverters to be connected with their DC busses in series.

In **2009** Jayanthi stated that the APF power circuit generally consists of DC energy storage unit, DC/AC converter and passive filter. Two main purposes serves by the DC capacitor (1) it maintains a DC voltage with a small ripple in steady state and (2) it serves as an energy storage elements to supply the real power difference between load and supply during the transient period.

In **2007** Kolhatkar stated that UPQC has the main advantage that it does not require any energy storage. UPQC can be designed to mitigate any sag above a certain magnitude , independent of its duration. This could result in a device that is able to compete with the uninterruptible power supply (UPS) typically used for the protection of low power and low voltage equipment. Separately configured DSTATECOM is less flexible than UPQC

In **1998** Aredes stated that universal active power line conditioner, universal active filter and universal power quality conditioning system are the different names of UPQC. It is a combination of a shunt (Active Power Filter) and a series compensator (Dynamic Voltage Restorer) connected together via a common DC link capacitor, which facilitates the sharing of the active power.

In **2012** Khadkikar stated that different topologies of UPQC are multilevel topology, single phase UPQC with two half-bridge converters, single phase UPQC with three legs, H bridge topology and UPQC is connected between two independent feeders to regulate the bus voltage of one of the feeders while regulating the voltage across a sensitive load in the other. For simultaneous compensation of voltage and current in adjacent feeders a new configuration used named multi converter unified power quality conditioner.

In **2002** Basu stated that Series converter of UPQC is most of time in standby mode and conduction losses will account for the bulk of converter losses during the operation. In this mode, the series injection transformer works like a secondary shorted current transformer using bypass switches delivering utility power directly to the load. UPQC without injection transformer has been designed.

In **2011** Khadkikar stated that UPQC is a Custom Power device and consists of combined series active power filter that compensates voltage harmonics, voltage unbalance, voltage flicker, voltage sag/swell and shunt active power filter that compensates current harmonics, current unbalance and reactive current.

In **2004** Ghose stated that the generated reference signal is used to produce gate switching signals of the inverter. The main modulation techniques used in DVR are space vector PWM modulation, dead beat control, PWM control and hysteresis control. The hysteresis control has the advantages of quick controllability, easy implementation and variable switching frequency capability. PWM method is widely used for gate signal generation in custom power application.

In **2008** Khadkikar stated that the shunt APF is usually connected across the loads to compensate for all current related problems such as the reactive power compensation, power factor improvement, current harmonic compensation and load unbalance compensation, whereas the series active power filter is connected in a series with a line through series transformer. It acts as controlled voltage supply and can compensate all voltage related problems, such as voltage harmonics, voltage sag, voltage swell, flicker etc.

In **2010** Zhilli stated that this converter has both regenerated energy generation and active power filtering capabilities. An inductance for output filtering of VSI is used to eliminate the harmonic at different frequencies. The different combinations of L & C filters to attenuate the switching ripple currents.

In **2014** Rojin R.K stated that the compensation performance of shunt and series active filter depends on the turning on and turning off of semiconductor switches used in shunt and series active filter. To generate the gate pulses for VSI switches the hysteresis current controller scheme is used. The fuzzy logic controller eliminates the drawback of PI controller. This system can compensate for voltage sag/swell, harmonics in voltage and current waveforms and reactive power, for making the load voltage balanced and sinusoidal.

In **2010** Metin Kesler stated that the UPQC system mainly compensate reactive power, voltage and current harmonics in the load under non-ideal mains voltage and unbalanced load current conditions. In the condition of unbalanced and nonlinear load current or unbalanced and distorted mains voltage conditions the APF control algorithms eliminates the impact of distortion and unbalance of load current on the power line, making the power factor unity. The series APF isolates the load voltages and source voltage and the shunt APF provides three phase balanced and rated currents for the loads.

In **2008** Fatiha Mekri stated that the UPQC has the ability to compensate sag, unbalanced voltages and current or voltage harmonics. The function of PAPF is to compensate current harmonics, to maintain the dc link voltage at

constant level and provide the variable required by the load. The function of SAPF is to mitigate the mains voltage perturbations. The current and voltage bands can be easily implemented with fuzzy logic to maintain the modulation frequency nearly constant for each control.

In **2011** Ahmet Take stated that control techniques play a vital role in the overall performance of the power conditioner. The rapid detection of the disturbance signal with high accuracy, fast processing of the reference signal, and high dynamic response of the controller are the prime requirements for desired compensation. A fuzzy logic controller has the rapid and effective compensation capability. The computational method is simpler than other control algorithms of reference extraction.

In **2008** Hind Djeghloud stated that the UPQC topology made up of a hybrid active power filter combination based on a common DC voltage for series and parallel APF. For both series and parallel APFs, we utilized the carrier based pulse width modulation PWM. The series APF controller forces load voltage to be sinusoidal, whereas parallel APF counter harmonic content from supply current.

In **2011** A. Mokhtatour stated that the UPQC has the capability of power flow control as well as power quality compensation. The controlling of UPQC was done by proper compositions of dqo and Fourier transform theories in sag, swell, interruption, unbalance and harmonic condition. In control of parallel active filter, active first order component of load current was determined as reference current for the reactive power compensation as well as current harmonics. In the reactive power compensation conditions, a PI controller was used for the control of load voltage phase in equal by source voltage source.

In **2010** Claudio A. Molina stated that under nonlinear and asymmetrical loads an UPQC with a Four-Leg Full-Bridge inverter (FLFB) used as a shunt active filter is used for improving the power quality. For the generation of the reference currents for the (FLFB) the instantaneous power theory in the dqz reference frame is used. The circulation of the active current in the PCC (point common coupling) side results in an optimal active power flow between the source and the load, but when the load has current harmonics it can produce distortion in the source current that can be undesirable.

In **2004** V. Khadkikar stated that in future, utility service provides will enforce more strict power factor and harmonic standards. One of the solutions towards this end is to employ a control technique based on unit vector templates generation has been proposed for UPQC. With the help of these techniques we can compensate input voltage harmonics and the current harmonics caused by the non-linear load.

III. CONCLUSION

A comprehensive review on the UPQC for compensation of voltage distortion and minimization of harmonics in the power supply at distribution level has been studied. UPQC in this context could be useful to compensate both voltage and current related problems simultaneously. Up to date development in the area of research and different aspects of UPQC have been briefly addressed. With the help of literature survey clearly identify particular application, utilization, configuration, and characteristic of the UPQC. It is desirable that the review on UPQC will serve as a useful reference guide to the researchers working in the area of power quality enhancement utilizing APFs. The control scheme of UPQC has the advantage of flexibility of selection of the power quality indices for which reference may be computed. The result of this study may be useful for selective compensation of different power quality problems and their combinations.

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