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Improvement of Power Quality by Using UPQC

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Abstract: *This paper present improvement of power factor in a long transmissions lines. In a transmission system to transfer the maximum power power factor is important role. Here improving the power factor means reducing the losses and increasing the efficiency.in order to achieving good power quality in this paper using UPQC The advance power electronic devices reduces harmonics in the supply system which creates a problem in the quality of power deliver .Good Power Quality is very much important for our day to day use of appliances in both industrial and domestic sectors. Researchers have tried and implemented many useful technology for removing all the voltage and current related harmonic occurrence problems which in turn improves the quality of power deliver to the power system. In this paper introduces different configurations of UPQC system for single phase and three phases. at the same time and helps in reduction of Total Harmonic Distortion.*

Key Points: *Power quality, Harmonic elimination, Unified power quality conditioner, D-Statcom, UPQC Configurations.*

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I. Introduction

In the present scenario non-linear loads have become extremely important and people are becoming dependent on it. Few of these non-linear loads are televisions, printing and fax machines, rectifiers, inverters, speed drives, AC, etc. Harmonics are introduced in the lines due to the extensive use of these loads in our everyday purpose. The stability of any electrical devices depends on its voltage and current waveforms. If the fundamental waveform is sinusoidal, and its harmonics are sinusoidal too then these harmonics occurs in integral multiples of the fundamental waveform. Due to this harmonic distortion created by nonlinear loads several problems are caused in the appliances used in our purpose like: motor getting overheated, increase in several types of losses, permanent damage of equipment in the worst case, high error in meter reading, etc. Hence removal of these harmonics or harmonic mitigation from voltage and current waveforms are of great concern for electrical engineers. Due to the harmonic's introduction in the lines by the nonlinear loads other problems of concern are voltage swell, voltage sag, flicker occurring in voltage, etc and thereby disturbing he overall power supply. In older days passive filters using tuned LC components were in very much use for improvement of power quality by removing voltage and current harmonics. But due to its high cost, resonance problems, large size and many more these filters are not in much use in the present days. All these problems are now improved by the use of active power filters (APF) and more advanced hybrid filters using several new technologies. Series Active Filter is utilized for mitigation of voltage quality problems and Shunt Active Filter (SAF) is helpful for removing the disturbances present in the current waveform.

POWER QUALITY PROBLEM

The voltage quality which a consumer gets for operation of load or given from some particular utility is very important. PQ problem deals with deviation of voltage/current from their ideal sinusoidal waveforms. The power quality became mainly poor at those typical locations where we connect the loads in the grid. Power Quality has its various definitions and importance as per the its usage by which we define them in the process. From designer perspective, PQ is defined as that there should be no variation in voltage and there should be complete absence of noise generated in grounding system. From the point of view of an utility engineer, it is voltage availability or outage minutes. For the end users how much feasible is the available power in order to drive various types of loads is defined as power quality.

POWER QUALITY ISSUE

Various power quality problems are Power surge, voltage spikes, notching, blackout, brownout, voltage flickering, harmonic, and voltage unbalance.

CUSTOM POWER DEVICES

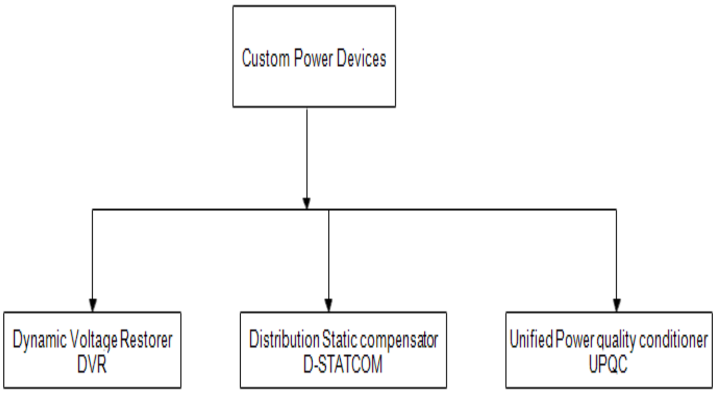

Fig1. Different types of custom power devices

The custom power devices are shown in above

1. Dynamic voltage restorer (DVR)
2. Distribution static compensator (D-STATCOM)
3. Unified power quality conditioner (UPQC)

a) Dynamic Voltage Restorer (DVR)

The problem of voltage sag impact on the transmission line it has reduce the power factor in order to overcome this problem introducing main device DVR. It is a modern and important custom power device for compensation voltage sags in power distribution systems. The Dynamic Voltage Restorer (DVR) is fast, flexible and efficient solution to voltage sag problem. The DVR is a series compensator used to mitigate voltage sags and to restore load voltage to its rated value.

b) Distribution static compensator (D-STATCOM)

The variation in voltage like, voltage sag, swell, flicker in voltage is minimized by using the static compensator (STATCOM). The STATCOM used in the distribution side is called as DSTATCOM. By use of the coupling transformer the DSTATCOM is connected in parallel to the line. The main function of D-STATCOM (Distribution Static Compensator) is Used for Mitigation of Power Quality Problems under unbalance caused by various loads and faults in distribution system. the phase and magnitude of the DSTATCOM output voltages allows effective control of active and reactive power exchanges between the DSTATCOM and the ac system. Such configuration allows the device to absorb or generate controllable active and reactive power.

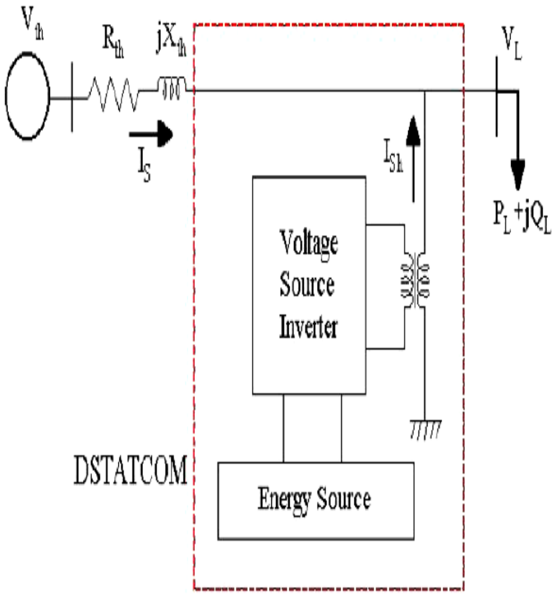

Fig2. Distribution static compensator (DSTATCOM)

c) Unified Power Quality Conditioner (UPQC)

UPQC (Unified Power Quality conditioner) is a equipment which is used for compensate for voltage distortion and voltage unbalance in a power system so that the voltage at load side is completely balance and sinusoidal & perfectly regulated and also it is used to compensate for load current harmonics so that the current at the source side is perfectly sinusoidal and free from distortions and harmonics. UPQC is a combination of a Shunt Active power filter and Series Active power filter. Here Shunt Active power filter (APF) is used to compensate for load current harmonics and make the source current completely sinusoidal and free from harmonics and distortions. Shunt APF is connected parallel to transmission line. Here Series APF is used to mitigate for voltage distortions and unbalance which is present in supply side and make the voltage at load side perfectly balanced, regulated and sinusoidal. Series APF is connected in series with transmission line. UPQC consists of two voltage source inverters connected back to back through a DC link capacitor in a single phase, three phase-three wire, three phase-four wire configurations. The inverter in shunt APF is controlled as a variable current source inverter and in series APF is controlled as a variable voltage source inverter. Earlier passive filters where also used for compensation of harmonics and voltage distortion but due to their many disadvantages they are not used nowadays.

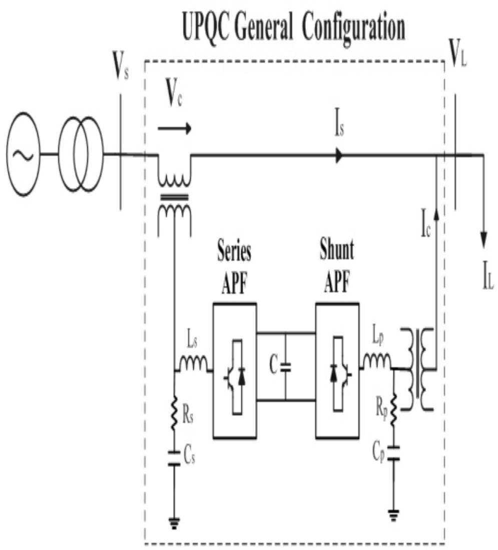

Fig3.Unified power quality conditioner

The various components used in UPQC are as follows:
1. Series inverter - The inverters connected in series to the supply known as the series active filter. This inverter behaves as a voltage source line which eliminates a voltage interruption.
2. Shunt inverter - The inverter connected in shunt to the supply line is known as shunt active filter. It eliminates the current related harmonics also minimize the reactive current in the load circuit.
3. DC link - The capacitor or inductor can be used as common DC link. As shown in fig. 4 the capacitor is used as DC link, which supplies the DC voltage.
4. LC filter - The output of the series active filter produces high switching ripples. The LC filter minimizes the ripples in a system. The LC filter acts as the low-pass filter.
5. Lsh Filter - The Lsh filter act as a high-pass filter. The ripples during switching mode are minimized by Lsh filter.
6. Injection transformer - The series injection transformer connected to series convertor.

VARIOUS CONFIGURATIONS OF UPQC
1) Topology of converter
2) Supply system
3) Configuration of system
4) Voltage sag compensation

The classifications of UPQC above given are explained below:
The classification on topology is divided into two types, i.e. Voltage source inverter and current source inverter.

a) VOLTAGE SOURCE INVERTER

A VSI based UPQC is built with two bridges of IGBT switches with anti parallel diode connected back to back with a dc capacitor as energy storage device ormer, ensures firstly the controllability of the active filter currents and secondly act as first order passive filter attenuating the high frequency ripples generated by the inverter. This filter may also be formed with third order (LCL) type. The voltage of dc capacitor used as energy storage device should be so high that the filter currents can be controlled to draw the load current harmonics through the supply filter. The theoretical minimum value for the voltage is the peak of the supply line-to-line voltage

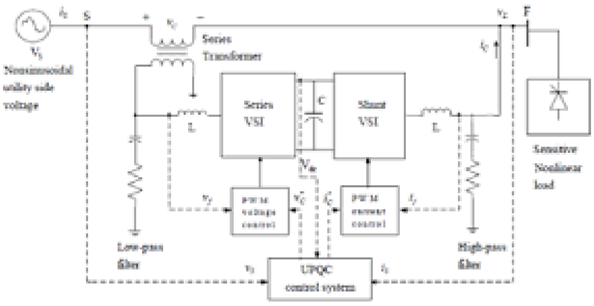

Fig4. VSI Based UPQC

b) CSI BASED UPQC

A CSI based UPQC is built with two bridges of IGBT switches connected back to back through an inductor of sufficiently large value as shown in fig

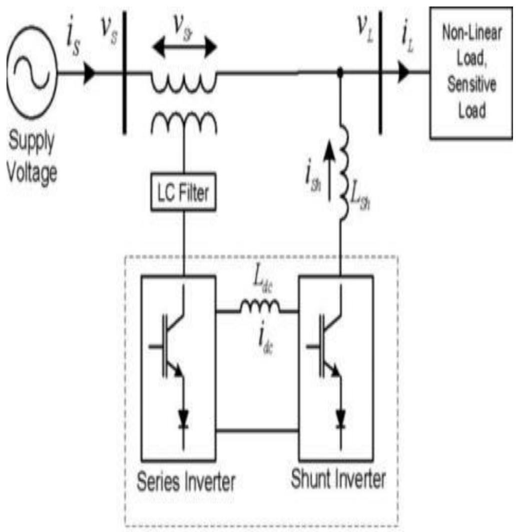

Fig5. CSI BASED UPQC

The series filter is connected to AC mains supply through a series transformer of suitable rating and a second order low pass filter formed by Cf and Lf . The size of filter capacitor must be selected carefully to make sure that no low-order harmonics are close to the resonant frequency of the LC tank circuit. The switches are under bidirectional voltage stress and maximum values of these are the peak value of the supply line –to-line voltage . A Fast Recovery Diode of similar rating is required to connect in series with each switch as to limit reverse voltage blocking. The use of series diode can be avoided by using reverse blocking IGBT. The energy storage element a dc inductor Ldc is designed to limit the dc current ripple to a specified value to limit ripples in Idc.The theoretical minimum dc link current is zero, but the current should be at least as high as the peak value of the compensating current. A R-L load connected through diode rectifier bridge will act as non-linear load to verify the system performance

CLASSIFICATION OF SUPPLY SYSTEMS:

The Classification of UPQC depending on the supply system is further divided into single-phase and three-phase supply system Further the Single and three phase can be Classified as single phase two wire and three phase three wire or three phase four wire System

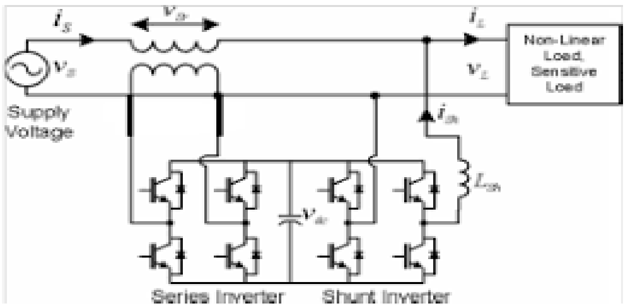

Fig6. Configuration of H- Bridge (1P2W)

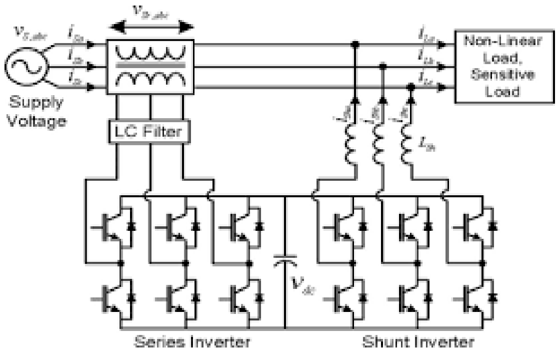

Fig7. UPQC of three phases three wires (3P3W)

The problems of power quality related to voltage harmonics are same in three phase and single-phase system. But in the system of a three phase the compensation in unbalance of voltage is required. The problems related to Current harmonics and reactive current of load are issues in the system of single phase. The unbalance in the current is considered in the system of 3P3W. Also, it needs the compensation of neutral current. For Minimizing the problems related to power quality are compensated by configuration of UPQC into the 1P2W system it consists of two inverters of H-Bridge with total eight switches.

CLASSIFICATIONS OF UPQC CONFIGURATIONS:
As compared to other devices, UPQC performs the two activities at the same time i.e. minimizes voltage disturbances as well as the current disturbances. The UPQC configurations are

a) Right and left shunt UPQC

The two inverters are connected Back to back in UPQC. Hence we can classify the UPQC based on the location of a shunt inverter in connection with series inverter. The shunt inverter placed at the right side is named as the right shunt UPQC (UPQC-R) , where as the shunt inverter placed at the left side called as the left shunt UPQC (UPQC-L).

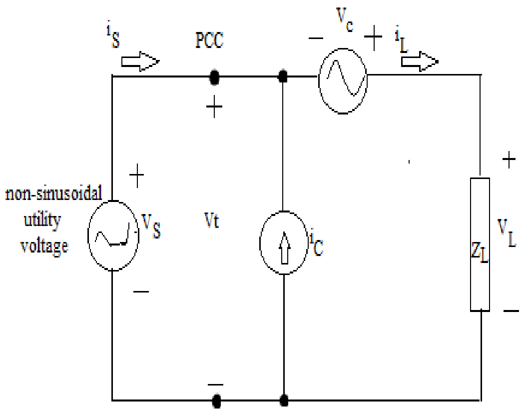

Fig8. RIGHT SHUNT UPQC

b) UPQC Interlined (UPQC-I)

When the two inverters of the UPQC are interlinked between two feeders the resulting configuration is known as interline UPQC (UPQC-I). Among the two inverters, one is connected in series and another in parallel with the two feeders of the distribution network. This configuration assists the control of the voltage of both the feeders simultaneously.

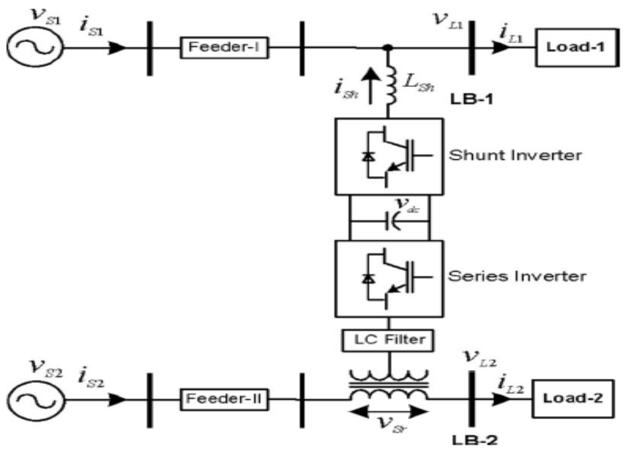

Fig9.UPQC Interlined

c) UPQC Multiconverter (UPQC-M)

Third converter is furthermore connected in the existing UPQC configuration to support the Dc bus voltage is known as UPQC-MC (Figure 10). The third converter can either be connected in series or in parallel with one of the converters and with the feeder

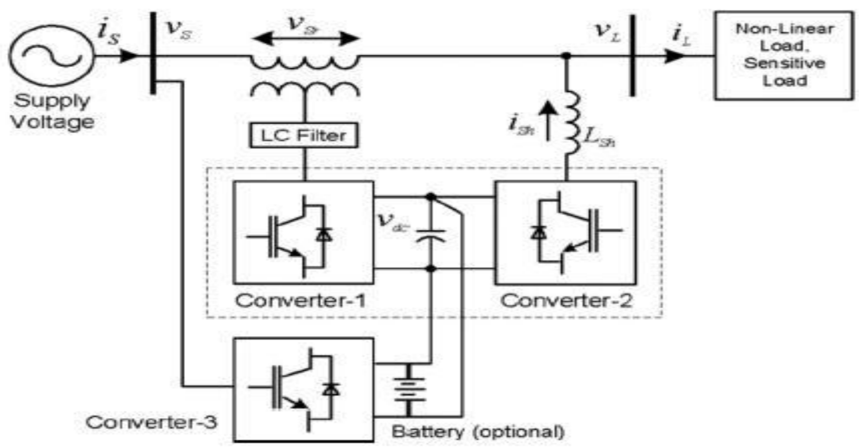

Fig10. UPQC Multiconverter (UPQC-M)

c) UPQC Modular (UPQC- Modular)

This configuration is obtained by connecting numerous H-bridges i.e. several UPQC in cascade for each phase. By use of multi terminal winding transformer the modules of H-bridge of shunt side of the UPQC are lined in series, whereas the modules of H-bridge of series side the UPQC is linked directly in series without using the series transformer. If the number of modules goes on increasing, the voltage of each H-bridge will get reduced.

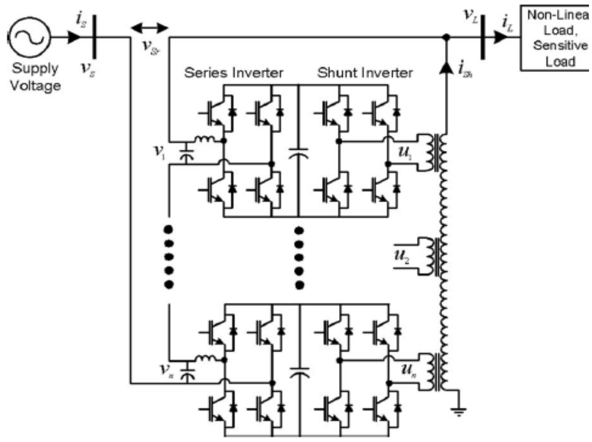

Fig11. System configuration of UPQC- Modular

e) **UPQC Distributed Generator (UPQC-DG)**

In this system UPQC combined with DC source this configuration is called UPQC-DG.In this system DG connected to DC link The voltage and current harmonics are mitigated and also the regulation of DG power is done by UPQC. The generated power by DG can be stored in battery as the backup in DG bus. One more benefit of giving power to the load during voltage interruptions is done by the UPQC integrated with DG. Next the power of DG is given in interconnected mode, i.e. to the load as well as to the grid or islanded mode in this the power is transferred to the selective loads.

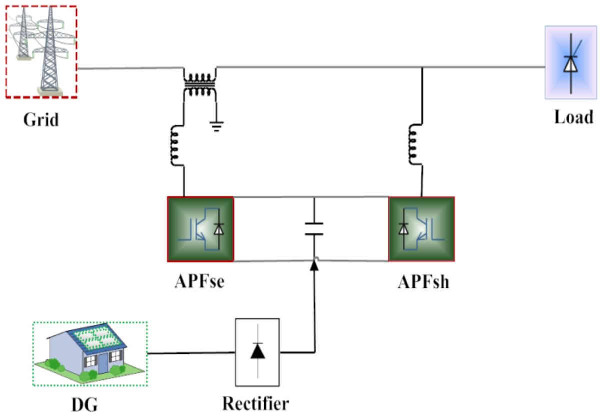

Fig12. UPQC WITH DG SYSTEM

One of the big problems of power quality is the voltage sag. For mitigating the sag in voltage the various methods by using UPQC is explained

1. **Control of active power (UPQC-P**) : For minimizing the sag in voltage, the active power is in use with the help of UPQC. Therefore, the name is UPQC-P. For minimizing the sag of voltage, series inverter of UPQC supplies the component of voltage in series. The supplied voltage is equal in phase and opposite in direction for minimizing the voltage sag.
2. **Control of reactive power (UPQC-Q):** The control of reactive power leads to minimize the voltage sag. As it injects the reactive power from UPQC, it is called as UPQC-Q. The control of power which is reactive in the voltage of quadrature there is injection of voltage from UPQC through a series inverter
3. **Loading of less Volt-ampere (UPQC-VA min):** There is need of reducing the load of VA for compensation of Voltage sag. Besides the injection of series voltage in phase or in quadrature, in the minimum VA, loading voltage of optimal angle is injected. Hence, the compensation of voltage with minimum VA ampere is known as (UPQC-VA min)
4. **Active and reactive power simultaneously (UPQC-S):** The working is same as that of UPQCVAmin. It injects the both active and reactive power. The voltage sag as well as voltage swell is done simultaneously by controlling series inverter. The name is given as UPQC-S as it gives active as well as reactive power (Complex power- S).

II. Conclusion:

This paper presents the review on UPQC to mitigate PQ issues. Available topologies its characteristics and classification of UPQC are presented. This paper resents a review of UPQC for improving the quality of electric power. Now after overall review of UPQC, the Distributed generation integrated with UPQC is main concern. In this the solar and wind i.e. renewable sources can be used, by keeping quality of power in acceptable limits. UPQC is one of the devices, which eliminates the voltage and current harmonics simultaneously. Different configurations of UPQC are briefly discussed in this paper

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