A Review on Power Quality Improvement in Distribution System using UPQC

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Abstract - *This paper introduces the operation of unified power quality conditioner (UPQC) as a universal active power conditioning device to moderate both current and in addition voltage distortions at an appropriation end of power system or framework network. The UPQC is outlined by combining a series active power filter (DVR) and shunt active power filter (DSTATCOM) which shares a regular DC link capacitor. Series compensator which is implied for voltage restoring is controlled by a fuzzy logic controller. Shunt compensator's operation is controlled by removing direct axis and quadrature axis current from load current and DC link voltage is kept up through a fuzzy logic controller. The execution of UPQC chiefly relies on how rapidly furthermore, precisely remuneration signs are inferred. The steady state and dynamic operation of control circuit in various load current and/or utility voltages conditions is considered through simulation results. The exhibited technique has adequate dynamic reaction with an extremely straightforward design of control circuit. The outlined UPQC is tried with static and exchanging nonlinear loads. It can moderate voltage sag/droop/swell, reactive power compensation, voltage fluctuations, harmonic elimination etc. under these load conditions.*

Key Words: Unified Power Quality Conditioner (UPQC), Distribution Static Compensator (DSTATCOM), and Total Harmonic Distortion (THD).

1.INTRODUCTION

Electric Power quality is a term which has captured increasing attention in power engineering in the recent years. Even though this subject has always been of interest to power engineers, it has assumed considerable interest in the 1990's. Electric power quality means different things for different people. To most electric power engineers, the term refers to a certain sufficiently high grade of electric service but beyond that there is no universal agreement. The measure of power quality depends upon the needs of the equipment that is being supplied. What is good power quality for an electric motor may not be good enough for a personal computer. Usually the term power quality refers to maintaining a sinusoidal waveform of bus voltages at rated voltage and frequency. The waveform of electric power at generation stage is purely sinusoidal and free from any distortion. Many of the Power conversion and consumption equipment are also designed to function under pure sinusoidal voltage waveforms. However, there are many devices that distort the waveform. These distortions may propagate all over the electrical network. In recent years, there has been an increased use of non-linear loads which has resulted in an increased fraction of non-sinusoidal currents and voltages in Electric Network. Classification of power quality areas may be made according to the source of the problem such as converters, magnetic circuit non linearity, arc furnace or by the wave shape of the signal such as harmonics, flicker or by the frequency spectrum (radio frequency interference). The wave shape phenomena associated with power quality may be characterized into synchronous and nonsynchronous Phenomena. Synchronous phenomena refer to those in synchronism with A.C waveform at power frequency. The main aspects of electric power quality may be categorized as:-

a) Fundamental concepts **d)** Modeling
b) Sources **e)** Analysis
c) Instrumentation **f)** Effects

Figure 1 shows some of the typical voltage disturbances.

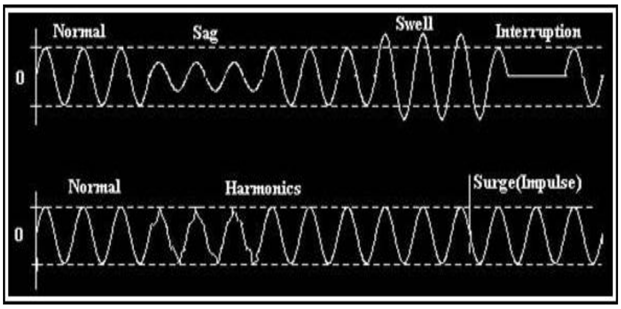

Figure 1: Typical Voltage Disturbance.

Custom power Devices like STATCOM (shunt active power filter), DVR and UPQC (combination of series and shunt active power filter) are the latest development of interfacing devices between distribution supply and consumer appliances to overcome voltage/current disturbances and improve the power quality by compensating the reactive and harmonic power generated or absorbed by the load.

2.Unified Power Quality Conditioner

Power Quality (PQ) has become an important issue to electricity consumers at all levels of usage. The PQ issue is defined as “Any power problem manifested in voltage, current, or frequency deviations that results in failure or misoperation of customer equipment.” The development of power electronic based equipment has a significant impact on quality of electric power supply. The switch mode power supplies (SMPS), dimmers, current regulator, frequency converters, low power consumption lamps, arc welding machines, etc, are some out of the many vast applications of power electronics based devices. The operation of these loads/equipments generates harmonics and thus, pollutes the modern distribution system. The growing interest in the utilization of renewable energy resources for electric power generation is making the electric power distribution network more susceptible to power quality problems. In such conditions both electric utilities and end users of electric power are increasingly concerned about the quality of electric power.

Many efforts have been taken by utilities to fulfil consumer requirement, some consumers require a higher level of power quality than the level provided by modern electric networks. This implies that some measures must be taken so that higher levels of Power Quality can be obtained.

Active power filters (APF) have been proposed as efficient tools for power quality improvement. Active power filters can be classified as series or shunt according to their system configuration. The series APF generally takes care of the voltage based distortions, while shunt APF mitigates current based distortions. The combination of series and shunt active power filter is called the unified power-quality compensator (UPQC). UPQC mitigates the voltage and current based distortion simultaneously as well as independently [1]. It is a versatile device that can compensate almost all power quality problems such as voltage harmonics, voltage unbalance, voltage flickers, voltage sags & swells, current harmonics, current unbalance, reactive current, etc. Recently more researches are going on mitigation of voltage sags and swells using UPQC. The swells are not as common as sags, but the effects of a swell can be more destructive than sag. The common cause of voltage sag and swell is sudden change of line current flowing through the source impedance. The steady state analysis of UPQC during voltage sag and swells on the system well presented in [3][4]. The main objective is to maintain the load bus voltage to be sinusoidal and the major concern is the flow of active and reactive power during these conditions. UPQC is commonly configured with two voltage source converters connected back to back through a DC link capacitor. Twin bridge configuration of inverter is used in series and shunt active power filter for eliminating harmonics. The shunt compensator which is meant for reactive power compensation and maintenance of DC link capacitor voltage is controlled by extracting direct axis and quadrature axis component of load current [2]. The reference currents are used for generating switching pulses of shunt compensator’s inverter. In order to regulate the DC-link capacitor voltage, a conventional PI controller is used to maintain the DC-link voltage at the reference value. The transient response of the PI controller in DC-link voltage will be very slow. To overcome this problem a better fuzzy logic controller is proposed to improve the transient response of the dc-link voltage [1]. The DC link capacitor voltage is maintained using a fuzzy logic controller [6]. The series compensator which is meant for voltage sag and swell compensation is also done using a fuzzy logic controller.

3.Literature Review

According to previous approaches the system consists of a distribution system in which the designed UPQC is connected before the load to make load voltage and current free from any distortions. The designed UPQC consist of a series active power filter and a shunt active power filter which shares a common DC link capacitor.

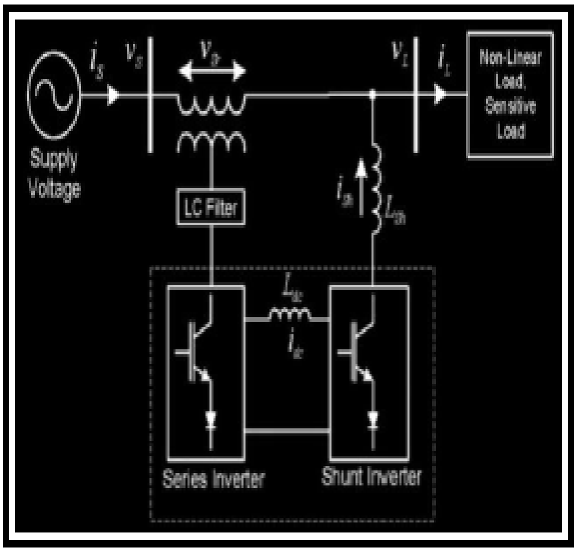

Figure 2: Basic Configuration of UPQC.

The objective of series compensator is to generate in phase voltage component to mitigate sag and generate out of phase component to mitigate swell. The shunt compensator is meant to supply reactive power while supplying nonlinear loads so that reactive power burden on source can be eliminated. The harmonic component of load current is also compensated by the shunt compensator. The entire distribution system is connected to unbalanced nonlinear switching loads to check the system performance.

4.Distribution Static Compensator

DSTATCOM is a shunt-connected custom power device specially designed for power factor correction, current harmonics filtering and load balancing. It can also be used for voltage regulation at a distribution bus. It is often referred to as a shunt or parallel active power filter. It consists of a voltage or a current source PWM converter

Figure 3.It operates as a current controlled voltage source and compensates current harmonics by injecting the harmonic components generated by the load but phase shifted by 180 degrees. With an appropriate control scheme, the DSTATCOM can also compensate for poor load power factor.
When the STATCOM is applied in distribution system is called DSTACOM (Distribution-STACOM) and its configuration is the same, or with small modifications, oriented to a possible future amplification of its possibilities in the distribution network at low and medium voltage, implementing the function so that we can describe as flicker damping, harmonic filtering and hole and short interruption compensation.

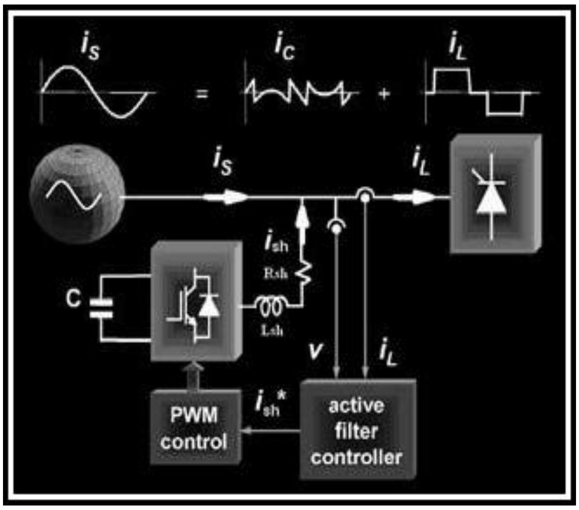

Figure 3: System Configuration of DSTATCOM.

Distribution STATCOM (DSTATCOM) exhibits high speed control of reactive power to provide voltage stabilization, flicker suppression, and other types of system control. The DSTATCOM utilizes a design consisting of a GTO- or IGBT-based voltage sourced converter connected to the power system via a multi-stage converter transformer. The DSTATCOM protects the utility transmission or distribution system from voltage sags and/or flicker caused by rapidly varying reactive current demand. In utility applications, a DSTATCOM provides leading or lagging reactive power to achieve system stability during transient conditions. The DSTATCOM can also be applied to industrial facilities to compensate for voltage sag and flicker caused by non-linear dynamic loads, enabling such problem loads to co-exist on the same feeder as more sensitive loads.

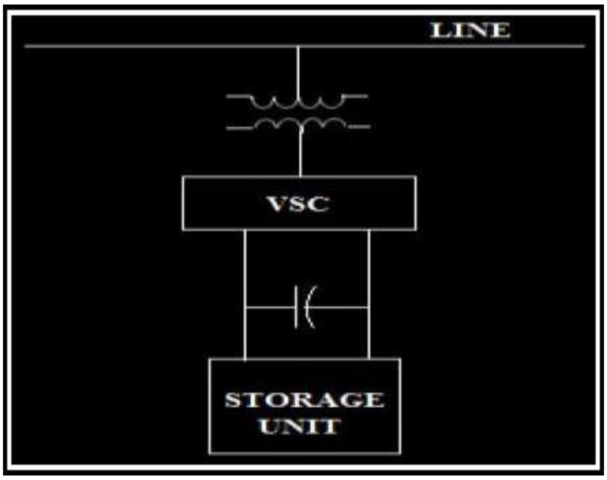

Figure 4: Basic Circuit Diagram of DSTATCOM.

The DSTATCOM instantaneously exchanges reactive power with the distribution system without the use of bulky capacitors or reactors. Figure 4 show the basic circuit diagram of distribution static synchronous compensator.

5. Total Harmonic Distortion

Total harmonic distortion is a complex and often confusing concept to grasp. However, when broken down into the basic definitions of harmonics and distortion, it becomes much easier to understand. Figure 5 imagine a power system with an AC source and an electrical load.

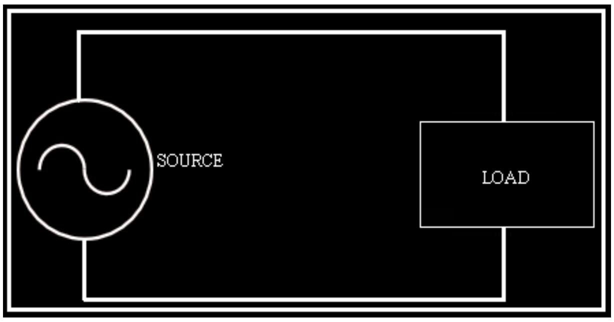

Figure 5: Power System with AC Source and Electric Load.

Now imagine that this load is going to take on one of two basic types: linear or nonlinear. The type of load is going to affect the power quality of the system. This is due to the current draw of each type of load. Linear loads draw current that is sinusoidal in nature so they generally do not distort the waveform show in Figure 6. Most household appliances are categorized as linear loads. Non-linear loads, however, can draw current that is not perfectly sinusoidal show in Figure 7. Since the current waveform deviates from a sine wave, voltage waveform distortions are created.

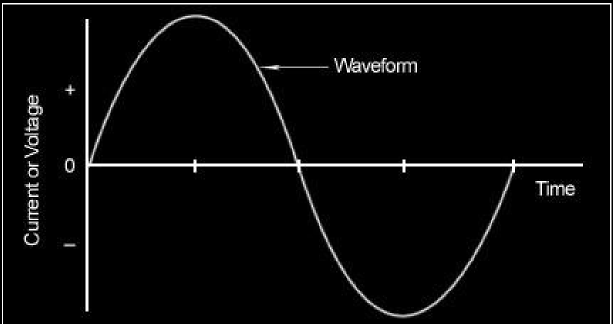

Figure 6: Ideal Sine Wave.

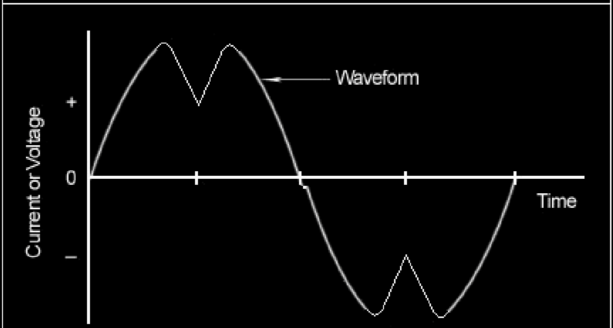

Figure 7: Distorted Waveform.

As can be observed from the waveform in Figure 7, waveform distortions can drastically alter the shape of the sinusoid. However, no matter the level of complexity of the fundamental wave, it is actually just a composite of multiple waveforms called harmonics. Harmonics have frequencies that are integer multiples of the waveform's fundamental frequency. For example, given a 60Hz fundamental waveform, the 2nd, 3rd, 4th and 5th harmonic components will be at 120Hz, 180Hz, 240Hz and 300Hz respectively. Thus, harmonic distortion is the degree to which a waveform deviates from its pure sinusoidal values as a result of the summation of all these harmonic elements. The ideal sine wave has zero harmonic components. In that case, there is nothing to distort this perfect wave. Total harmonic distortion, or THD, is the summation of all harmonic components of the voltage or current waveform compared against the fundamental component of the voltage or current wave:

$$THD = \frac{\sqrt{(V_2^2 + V_3^2 + V_4^2 + \cdots + V_n^2)}}{V_1} \times 100\%$$

The formula above shows the calculation for THD on a voltage signal. The end result is a percentage comparing the harmonic components to the fundamental component of a signal. The higher the percentage, the more distortion that is present on the mains signal.

6. CONCLUSIONS

According to previous approaches introduced an UPQC model, created with the important parts and controllers keeping in mind the end goal to exhibit its adequacy in looking after power quality anytime in the distribution line. The design UPQC is tried utilizing with various load conditions. The introduced UPQC with its controller is abler voltage sag/droop/swell pay, current consonant pay, responsive force pay, load adjusting and so forth. The reenactment results appears compelling and exact force quality control utilizing fluffy rationale controller reactive power compensation, voltage fluctuations, harmonic elimination etc. under these load conditions. The outcomes show effective and accurate power quality control using fuzzy logic controller.

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