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A Survey on Unified Power Quality Controller for Different types of Loads

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Abstract
In this paper, a survey on Unified Power Quality Conditioning (UPQC) system has been presented for different types of loads. It is explained that the UPQC is capable of compensating voltage and current disturbances simultaneously in a two bus system. It explains the different properties, characteristics and features about UPQC, FACTS devices, power quality problems and technique. Various papers discussed about the advantages of UPQC over other power quality enhancing devices.

Keywords: FACTS, UPQC, Power Control, Total Harmonic Distortion, Automatic Power Factor Correction, Dynamic Flow Controller (DFC).

Introduction

The purpose of a power transmission line is to group generating stations and Load centres. It is generally constrained by line impedance, operating variables voltages and currents. Therefore generating stations may not be able to supply power demand. In addition now a days deformation of Power Quality which is effected by non linear loads and electronically switched devices is also a constraint. This affects the cost and reliability of the supply of the electricity. This may lead to large power flows with inadequate control, excessive reactive power in various parts of the power system, large dynamic swings between different parts of the system, thus the full potential of transmission line can not be utilized. This need emerged new technology Flexible AC Transmission systems (FACTS). FACTS technology uses switching power electronics to control power flow.

The FACTS technology is a collection of controllers, which can be applied individually with others to control one or more of the interrelated system parameters. FACST controllers can enable a transmission line to carry power closer to its thermal rating. The idea of FACTS is to use power electronics for controlling power flow in a transmission line and allowing it to fully load up to its capability.

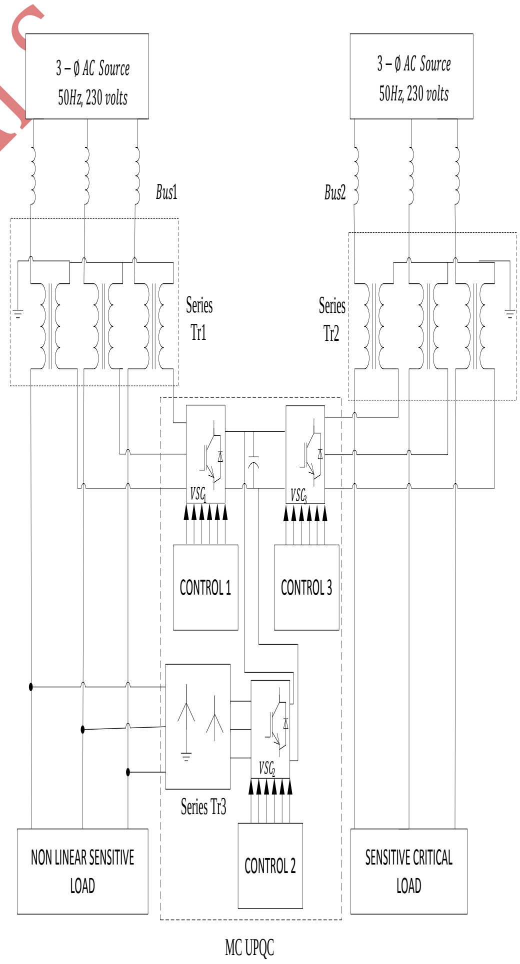

Fig.1 UPQC System Configuration

The thyristor based FACTS devices are Static VAR compensator (SVC), Thyristor Controlled Series Compensator (TCSC) and Dynamic Flow Controller (DFC). These devices have low losses due to their low switching frequency.

The other type of FACT devices are voltage source converters based uses mainly Insulated Gate Bipolar Transistors (IGBT) or Insulated Gate Commutated Thyristor (IGCT) as devices. The FACT devices are namely Static Synchronous Compensator (SSC or STATCOM), Static Synchronous Series Compensator (SSSC) and Unified Power Flow Controller (UPFC). These types of FACTS controllers are more advanced Technology. The use of IGBT with Pulse Width Modulation (PWM) allows high modulation frequencies to get low harmonics in the output voltage in magnitude and phase. With the increase in switching frequency, the switching losses also increase.

The shunt compensating FACT devices SVC and STATCOM are primarily for reactive power compensation, a current is injected in to the system at the point of common coupling and it's a good way to control the voltage. The SVC provides smother and precise control in comparison with mechanically switched shunt compensation and improves stability. The STATCOM in comparison with SVC provides power quality in against even dips and flickers. Shunt compensator can not provide control of the power flow in the lines.

The series compensating FACT devices TCSC and SSSC are also for reactive power compensation. These devices drive the voltage in to the line and impact the current and power flow directly. A conclusion can be made that if the current, power flow or damp oscillations are to be controlled then series compensator is used.

Power flow devices shift power flows from overloaded parts of the power system to areas with free transmission capability. Phase Shifting Transformer (PST) are the most common devices in this area but they have limitations like low control speed together with a high wearing and maintenance. Unified Power Flow controller (UPFC) provides power flow control together with independent voltage control. The Dynamic Power Flow Controller (DFC) is introduced to fill the gap between UPFC and PST. Thyristor switched capacitor with a PST will provide dynamic controllability over parts of the control range.

The application of FACTS in distribution systems has resulted new type of compensating devices. A unified power-quality conditioner (UPQC) is the extension of the unified power-flow controller (UPFC) concept at the distribution level. It consists of combined series and shunt converters for simultaneous compensation of voltage and current imperfections in a supply feeder.

In this paper, a new configuration of a UPQC called the multi converter unified power-quality conditioner (MC-UPQC) is presented. The proposed topology can be used for simultaneous compensation of voltage and current imperfections in both feeders by sharing power compensation capabilities between two adjacent feeders which are not connected. The system is also capable of compensating for interruptions without the need for a battery storage system. The performance of the UPQC and the proposed control algorithm has been validated in MATLAB/SIMULINK environment on a two bus system.

System configuration and Principle of operation:

The proposed system configuration of a UPQC is shown in above Fig1. The system configuration has been proposed to a two bus system. The system consists of two bus bars connected to a non linear sensitive load and a sensitive critical load. The harmonics and disturbances caused by these loads to the both feeders are simultaneously cleared using three VSCs. System consists of three VSCs (VSC1, VSC2, and VSC3) which are connected back to back through a common dc-link capacitor. In the proposed configuration, VSC1 is connected in series with BUS1 and VSC2 is connected in parallel with load L1 at the end of Feeder1. VSC3 is connected in series with BUS2 at the Feeder2 end. Each of the three VSCs in Fig. 2 is realized by a three-phase converter with a commutation reactor and high-pass output filter. As shown in Fig, all converters are supplied from a common dc-link capacitor and connected to the distribution system through a transformer. Secondary (distribution) sides of the series-connected transformers are directly connected in series with BUS1 and BUS2, and the secondary (distribution) side of the shunt-connected transformer is connected in parallel with load L1. The aims of the UPQC shown in Fig are:

1) To regulate the load voltage against sag/swell and disturbances in the system to protect the nonlinear/sensitive load L1;

2) To regulate the load voltage against sag/swell, interruption, and disturbances in the system to protect the sensitive/ critical load L2;

3) To compensate for the reactive and harmonic components of nonlinear load current at Load 1.

PREVIOUS WORK

In [1], the authors analysed that it very tough to serve a controlled voltage to the loads, balanced and with low harmonics in distribution system. This paper presents a unique method to improve the power quality by using Dual UPQC. Dual UPQC contains two active filters connected in series and shunt combination by using PWM technique called UPQC for unbalance system. This method is able to compensate with non-liner load current and improves the power quality.

In [2], the authors presented a review and analyzed the property of different power electronic devices used to maintain power quality. The power electronics-based devices are called custom power (CP). Custom power devices are very useful to control reactive power at the load side. The network reconfiguring devices are solid state current limiter (SSCL), solid state breaker (SSB), and solid-state transfer switch (SSTS). The compensating devices are used as UPQC, DSTATCOM, DVR are used to mitigate harmonics and other power quality issues. presents a method analyzed a three-phase unified power quality conditioner (UPQC) having cross-phase connection and designed to reduces power quality problems and single-phase fault. The paper discussed the control strategies. This paper introduced the cross-phase connected UPQC and two multi-loop control schemes for series and parallel VSC. This paper emphasized that the proposed control strategy for cross-phase connected UPQC can compensate voltage sag up to 100%. The results demonstrate that the cross-phase connected UPQC is capable of regulating load terminal voltage and compensating load current changes simultaneously and effectively.

In [3], the authors introduced a method of open UPQC for the PQ improvement, they done an analysis a shunt unit and their performance. In this paper they are discussed about double conversion UPS, series and parallel double conversion in line UPQC, two parallel double conversions in line, shunt unit conversion and an open UPQC. This paper introduces an O-UPQC as a tool to enhance PQ level in LV distribution and its focus in on shunt units.

In [4], the authors presented a philosophy for the improvement of power quality using reduced rating star connected hybrid UPQC. This system consists a three wire UPQC, star connected transformer and LC filter. The performance of proposed UPQC scheme is used which completely compensate the source current harmonics, load current harmonics, voltage sag\swell and neutral current.

In [5], the authors proposed a topology of a Multi-objective planning for reactive power compensation for radial distribution networks with UPQC Allocation using particle swarm optimization that helps us to known about the optimal location, the optimal reactive power compensation at the location and the parameters of UPQC can be analyzed. The modified UPQC-PAC system is also used to control active power compensation in distribution system. These two systems are used to maintain.

In [6], the authors presented a three phase UPQC for PQ improvement by using unit vector template generator (UVTG) technique for compensation of voltage harmonics, sag\swell, current harmonics. The proposed UPQC have a series and shunt active filter (AF) in cascade formation connected by a common DC-link capacitor. This arrangement is useful for 5th and 7th order harmonics and THD control.

In [7], the authors proposed a scheme for Improving PQ of a distribution grids using multi-level convertors based UPQC. In this paper, the Power Quality (PQ) in distribution system is discussed. These techniques use a three-level converter-based UPQC that can be controlled by a SPWM method, can a resolve the disturbances at distribution system. The performance of UPQC on IEEE 14-bus system is analyzed by using different simulations on PSCAD/ EMTDC software. The simulation result gives the performance of UPQC and its action against the voltage sag\swell. UPQC reduces THD and amplitude of harmonics.

In [8], the authors presented a control strategy for a single-phase transformer less three-leg UPQC based on space vector modulation. In these two modulation modes, MM1 & MM2 are used to derive TL-UPQC configuration. When MM1 can be use, in this one leg of TL-UPQC works at the line frequency so that efficiency of the system is enhanced. Harmonics presents in current can reduced by usingMM2. So, shunt converter output current ripple which is introduced by the modulation process can be minimized and improves.

In [9], the authors discussed methodology for the management of reactive power sharing and improvement of PQ with new SRF-PAC based on UPQC for shearing of reactive power shunt and series inverters of identical rating are used, and mathematical analysis can be done for maximum power angle estimation. This analysis helps to control triggering of the SRF-PAC based device so that effective maximum injection of reactive power for different PQ issues can be handle out.

In [10], the authors proposed a method for the improvement of PQ and elimination of their issues. Advance hybrid filters of series and shunt APF are used, series APF used for voltage disturbance and shunt APF used for current disturbance. Unit vector template used as controlling technique for series APF and this scheme also utilize phase locked loop (PLL), for shunt APF instantaneous reactive power theory has been used to model. It is innovative and coast effective compensation technique.

In [11], the authors explained nine switch shunt and series UPQC instead of conventional 12 switch by using PSO based control technique that enhance its operation quicker and stress on switch also decreased by 33% and other PQ issues are perfectly managed, so these system is very effective to decrease burden on switch and power loss can also be decreased.

In [12], the authors presented a novel UPQC provide a quick and efficient method for the detection of fault due to sag\ swell in disturbed loads. Increase in nonlinear loads creates a power quality issues. Proposed controller method is basically used for wind power plants for the controlling of the reactive power, harmonics and other issues.

Conclusion:

It can be concluded from the previous discussions that different control mechanisms can be employed for the power control of UPQC. In this paper, the different power control mechanisms have been explained in detail. Also, the different approaches adopted by contemporary works have been cited.

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