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Integrated voltage compensator for three phase system using UPQC with PV source

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ABSTRACT

This paper presents a simplified control technique for a dual three phase topology of a unified power quality conditioner – Buck-Boost Unified Power Quality Controller (UPQC). The UPQC is composed of two active filters, a series active filter and a shunt active filter (Parallel active filter), used to eliminate harmonics and unbalances. Different from a conventional UPQC, the UPQC has the series filter controlled as a sinusoidal current source and the shunt filter controlled as a sinusoidal voltage source. Therefore, the pulse with modulation (PWM) controls of the UPQC deal with a well-known frequency spectrum, since it is a controlled using voltage and current sinusoidal references, different from the conventional UPQC that is controlled using non sinusoidal references. In this paper, the proposed design control, power flow analysis, and experimental results of the developed prototype are presented. The UPQC which can be used at the PCC for improving Power quality is modeled and simulated using proposed control strategy and the performance are compared by applying it to a distribution system without compensation, shunt compensation, series compensation and with UPQC. The performance of this UPQC has been evaluated with a typical industrial load with realistic parameters supplied by polluted distribution network.

Keywords: Power quality, UPFC, DC Link capacitors, FACTS, DVR & DSTATCOM, VSI, Hysteresis PWM Controller

INTRODUCTION

The economy invested in the Distribution System is large enough to take into account the concept of equipment protection against various disturbances that affect the reliability of not only the distribution system but the entire power system incorporation Generation and Transmission too. The wide acceptance of sophisticated electronic device at the utility end deteriorates the quality of supply and utility is suffering from its bad effects on large scale. The various Power quality problems [1] encompass the voltage sags, voltage dips and voltage swells, flickers, harmonics and transient accompanied by unbalanced power, which are results of various faults with three phase fault being the most severe among all, starting of induction motor which is most often used due to its rugged construction, switching off large loads and energizing of capacitor bank. The higher index of reliability and power quality [2] to satisfy the customer has reflected the need for the development and application of compensation systems. Compensating systems [3] also known as

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the custom power devises [CPD] offer a handful protection and security to the system under observation. They tend to absorb the various disturbances by injecting appropriate voltage, current or both into the system, thereby relieving the main source from meeting the reactive power demand of the load. This dissertation attempts to explain the various control strategies providing a reliable solution to the faulted system with the help of UPQC (Unified Power Quality Controller). This series conditioner device is capable of generating or absorbing real and reactive power with the help of its essential components, namely power circuit and control circuit. Various control techniques are available to obtain a controlled output voltage, to be injected into the system. There are known as linear and non-linear techniques. A PI controller with a linear structure offers satisfactory performance over a wide range of operation [5]. The problem encountered by the controller is the setting of PI parameters i.e. the gains (Kp, Ki) in the influence of varying parameters and operating conditions, the fixed gains of liner controller don't adapt accordingly to give good dynamic response. To overcome the problems faced by a liner technique, non-liner technique is an effective solution [10]. The recommended system use the PI, Hysteresis [20] [21] [22] and Hybrid PI- Hysteresis [28] controllers to the investigate the performance level of various controllers in a regard to increase capability of the existing system by creating immunity.

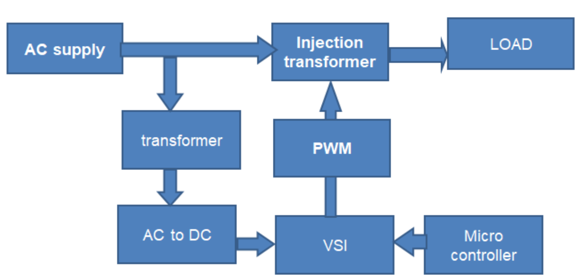
SCOPE OF WORK

Power Quality gains its importance with the introduction of sophisticated electrical gadgets. Nowadays, a non-liner load causes the distortion of sinusoidal waveform which adversely affect the Power Quality performance. Switching of heavy loads, capacitors, Transformers and unbalance loads on a three phase system are some of the sources that contribute to voltage sag. Due to this voltage sags, the performance and the life of the equipments deteriorate considerably. This calls for the introduction and usage Custom Power Devices (CPD) with philosophy of improvement of the power quality. As per the literature review, the UPQC provides excellent voltage regulation capabilities in the influence of various power quality problems.

Objective of the proposed dissertation

The objective of the proposed dissertation is to promise power quality and reliability in the distribution network with the simulation of various control strategies of UPQC. The three control schemes namely PI, Hysteresis, PI –Hysteresis have been compared on account of the amount of compensation being injected into the system under voltage sag condition for linear and Non-linear loads. The three controllers provide almost equivalent compensation of linear loads but the difference in compensation occurs during non-linear loads. The capability of UPQC control schemes is demonstrated using MATLAB/SIMULINK simulations. The simulink models have been developed for the distribution networks with linear and non-linear loads. The effectiveness of PI controller based UPQC, hysteresis controller based UPQC and hybrid PI-Hysteresis controller based UPQC in these distribution network is investigated.

EXISTING METHOD

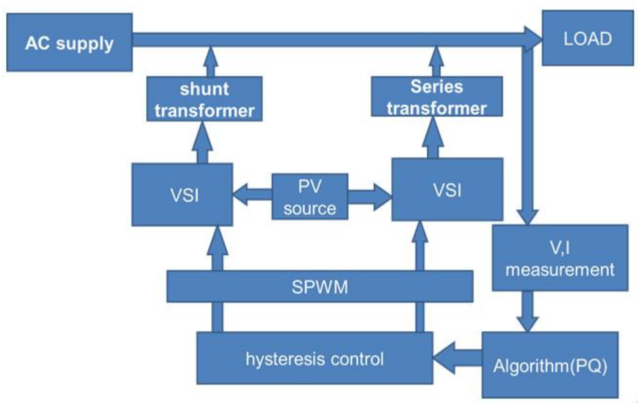


The users demand higher power quality to use more sensitive loads to automate processes and improve living standards. Some basic criterions for power quality are constant RMS value, constant frequency, symmetrical three-phase, pure sinusoidal wave shape and limited THD. These values should be kept between limits determined by standards if the power quality level is considered to be high. The economic losses due to power interruptions and disturbances can be quit high as a result of the important processes controlled and maintained by the sensitive devices.

PROPOSED SYSTEM

The integrated solution to the power quality problems encountered in the distribution area is "Custom Power". It focuses on reliability and quality of power quality.

Custom power technology, the low- voltage counterpart of the more widely known flexible ac transmission system (FACTS) technology, aimed at high-voltage power transmission applications, has emerged as a credible solution to solve many of the power quality problems relating to continuity of supply at the end-user level [4]. Mitigation is in the harmonic context which is often seen as reduction of harmonic voltage or current distortion.



WORKING

However the problem can also be mitigated by improving the immunity of equipment. The mitigation methods include reducing the number of faults, faster fault clearing, improved networks design and operation, improved end-user equipment [5]. The higher index of reliability and power quality to satisfy the customer has reflected the need for the devolvement and application of compensation systems. Compensating systems also known as the custom power devices offer a handful of protection and security to the system under observation. A custom power device is a reliable and flexible solution to the consumers regarding the power supply. They tend to absorb the various disturbances by injecting appropriate voltage, current or both into the system, thereby relieving the main source from meeting the reactive power demand of the load. Various custom power devices covering a wide range of flexible controllers and capitalize on evolution of power electronic controllers are widely used to compensate voltage sag / swells in the system [3]. The custom power devices used for transmission system includes static synchronous compensator (STATCOM), Static synchronous series compensator [SSSC], interline power quality conditioner (IPFC) and Unified Power Quality Conditioner (UPQC) and for distribution system are distribution static synchronous compensator (DSTATCOM), Unified Power Quality Control (UPQC), active Power filter (APF), Unified Power quality Conditioner (UPQC) etc. there are various other custom power devices such as battery energy storage system (BESS), Surge Arrester (SA), Super conducting Magnetic

Energy System (SMES). Static Electronic tap Changer (SETC), Solid State

Transfer Switches (SSTS) and Solid State Fault Current Limiter (SSFCL).

In this work, effectiveness of UPQC to compensate the load voltages investigated. It is a series compensating device that helps in increasing the immunity of the equipment and reliability of the system by regulation of voltage in the system. The whole work is concentrated around UPQC and its various control strategies.

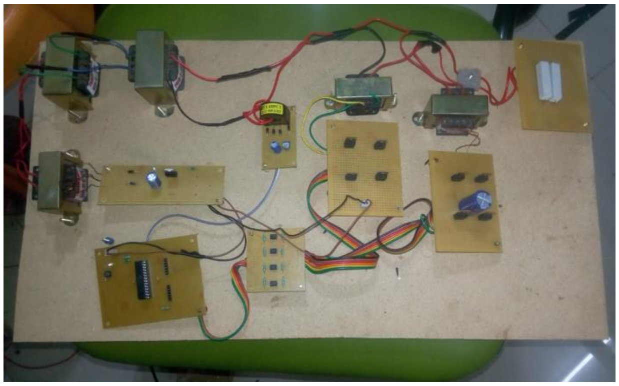


Figure.3. Hardware for Integrated Voltage Compensator for Three Phase System using UPQC with PV Source.

APPLICATION OF UPQC

The First UPQC was installed in North America in 1996- a 12.47 KV system located in Anderson, South Carolina [13]. Practically, the capability of injection voltage by UPQC system is 50% of nominal voltage. This allows UPQCs to successfully provide protection against sags to 50% for duration of up 0.1 Seconds. Furthermore, most voltage sag rarely reach less than 50%. The Unified Power Quality Controller is also used to mitigate the damaging effect of voltage swells, voltage unbalance and other waveform distortions.

UPQCs of capacities up to 50 MVA have seen applications to critical loads in food processing, semi conductor and utility supply. Cost and installation constrains limit these to where there is clear need for constant voltage supply.

System parameters

Sl.No	**System Quantities**	**Standards**
1	Source	3 Phase, 13 KV, 50Hz
2	Inverter Parameters	IGBT Based 3 Amps, 6 Pulse carrier frequency -1080 Hz sample time = 50 µSec
3	PI Controller	Kp=0.5, Ki=50, Sample time = 50µSec
4	RL Load	Active Power = 1 KW, Reactive Power = 400 VAR
5	Three winding Transformer	Y/Δ/Δ 13/115/115KV
6	Two Winding Transformer	Δ/Y 115/11KV

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RESULT

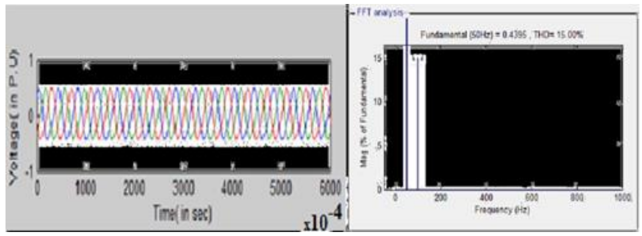

Figure.4. Load Voltage Wave form and its Frequency Spectrum when compensated using Hysteresis controller based UPQC.

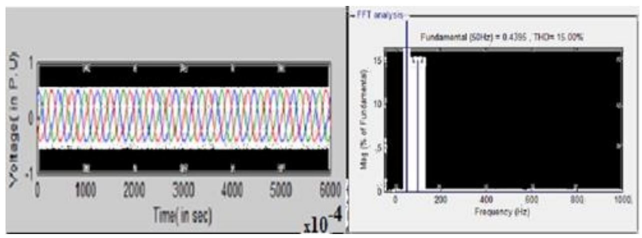

Figure.5. Load Voltage wave form and its frequency spectrum when compensated using hysteresis controller based UPQC.

CONCLUSIONS

In this work, cost effective and reliable custom Power concept, Unified Power Quality controller is used to medicate the voltage sags in the distribution System, thereby improving the performance of the system. The various control strategies are employed and tested for 11KV distribution system. The PI controller based UPQC, Hysteresis controller based UPQCs and PI Hysteresis controller based are connected step by step in the in the compensated feeder to compare their performances. The effectiveness of different controller techniques based UPQCs for static linear and static non-linear loads have been investigated. As seen from the load voltage wave form and frequency spectrum of uncompensated system in fig 5.3, the THD level is reduced effectively from 25% to a much less value of 16.68% as in fig 5.11. load voltage waveforms and frequency spectrum of hybrid control scheme for static non-linear loads in fig5.11 depicts that the harmonies are effectively reduced to a less value as compared to 23.70% with PI controller in fig 7 and 17.49% with hysteresis controller in fig 9/ simulation results indicate that the non-linear control techniques provide better compensation to the system as compared to the linear PI technique based UPQC connected to the feeder during static non-linear loads.

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