

POWER QUALITY IMPROVEMENT USING UNIFIED POWER QUALITY CONDITIONER: REVIEW

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ABSTRACT

We must raise the standard of the electricity our devices and appliances use in order to get the most use possible out of them. Several tools are at hand that can improve power quality. Only a few of the equipment that may be utilised to improve power quality in industries are "Distribution Static Synchronous Compensator (DSTATCOM), Static VAR Compensator (SVC), Dynamic Voltage Restorer (DVR), and Unified Power Quality Compensator (UPQC)". An example of an active power filter is the UPQC. It aids in reducing PQ issues related to voltage and current, together with power factor correction and the integration of renewable energy sources into the distribution network. This research covers topologies, compensation schemes, control theories, and technological developments in recent years. The results of this study are expected to be crucial in supporting researchers in using the UPQC.

Keywords: Voltage sag; fuzzy adaptive control; fuzzy adaptive control; solar photovoltaic; unified power quality conditioner.

1. INTRODUCTION

A crucial concern in the distribution system is power quality. A characteristic of electricity is simply referred to as power quality, or the purity of the transferred energy. An electrical grid's main function is to deliver dependable power for usage by a variety of electrical equipment. The increased usage of power electronic controlled applications across various corporate sectors has caused a recent focus on power quality. These programmes control or transform AC electricity to provide electrical loads, among other things. Due to non-linear loads, issues with harmonic distortion limitations have emerged. Since nonlinear loads are so common, power quality problems will eventually show themselves. One effective way to protect sensitive loads is to install a unified power quality conditioner (UPQC) at the Point of Common Coupling (PCC). Whether in series or in shunt, every APF in a UPQC is linked to a common dc source. Almost all power quality problems, including voltage harmonics, voltage imbalance, voltage flickers, voltage sags and swells, current harmonics, current unbalance, reactive current, etc., may be fixed by this versatile device. The Unified Power Quality Conditioner (UPQC) has evolved into one of the most comprehensive custom power solutions available to address non-linear harmonic producing loads and the effects of utility voltage interruption on sensitive industrial loads. Maintaining command of UPQC's power filters is essential for ensuring its optimal performance. To regulate them, there are several topologies has been introduce. Control strategy plays a key part in the overall functioning of the power conditioner. Desired compensation requires three main things: (1) rapid and accurate detection of the disturbance signal; (2) rapid processing of the reference signal; and (3) strong dynamic responsiveness from the controller. The UPQC's technique for controlling itself is determined by the method used to generate a suitable switching pattern or gating signal in response to the command compensatory signal. Many different theories and procedures have been developed or used throughout the years to derive the reference signal from the observed distorted signal. Some of these are detailed in this study. Here Since energy is a need for daily living, it must be delivered to consumers in a consistent, high-quality manner. Due to rising increase in consumption and power generation, the transmission of electricity in the connected cooperative electrical system is gradually expanding. Worldwide transmission systems are constantly changing and being reorganised. They are getting weighed down more and more. For the transmission networks to respond to more varied generation and load patterns, they must be adaptable. The three control parameters that regulate the flow of power in the transmission system are voltage magnitudes, phase angles, and line reactance. When two locations are connected by a symmetrical, lossless transmission line (Fig. 1), the power flow P in the line can be stated as follows:

1.1 Unified Power Quality Conditioner (UPQC)

A Unified Power Quality Conditioner (UPQC) is a device that is very much in similar in construction to a Unified Power Flow Conditioner (UPFC). The UPQC utilizes two voltage source inverters that are connected to energy storage capacitor. One of these is connected in series and the other is connected in shunt with the ac system. The UPQC is one of the most powerful custom power devices, which can mitigate both voltage and current related problems simultaneously. The UPQC is a combination of back-to-back connected series and shunt APFs to a common dc link voltage. The series APF compensate all voltage harmonics and shunt APF cancels current-based distortions.

And improve power factor by compensating reactive component of load current. In this paper, the improved synchronous-reference-frame with SPWM based control method for the UPQC system is optimized without using transformer voltage, load, and filter current measurement, so that the numbers of the current measurements are reduced and the system performance is improved.

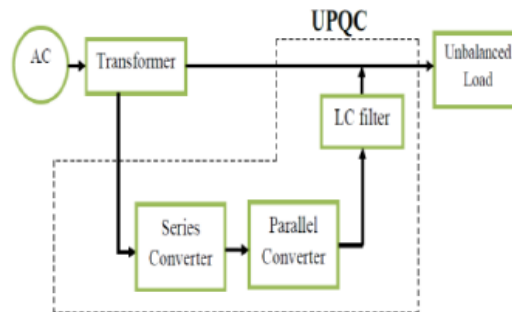


Figure 1: Block Diagram of UPQC

In the figure 1 configuration of UPQC is depicted. The main purpose of the series active filter is harmonic isolation between a sub transmission system and a distribution system. In addition, the series active filter has the capability of voltage flicker/imbalance compensation as well as voltage regulation and harmonic compensation at the utility-consumer point of common coupling (PCC). The main purpose of the shunt active filter is to absorb current harmonics, compensate for reactive power and negative sequence current, and regulate the dc link voltage between both active Filters.

2. LITERATURE REVIEW

A. Javadi, L. Woodward, and K. Al-Haddad, [3] the trio in their paper titled “Real-time implementation of a three-phase THSeAF based on VSC and p+r controller to improve power quality of weak distribution systems,” has proposed a single-phase transformer-less hybrid series active filter (THSeAF) based on duo-neutral-point-clamped (D-NPC) converter to address distribution level power quality to investigate experimentally the efficiency of the hardware-in-the-loop (HIL) implementation for power electronics applications. This benchmark contributes to demonstrating the capability and efficiency of such real-time implementation for smart grid power quality (PQ) analysis which requires fast switching process with small sampling time. Such applications require the compensator to address major power quality issues related to a nonlinear load.

Y. Singh, I. Hussain, B. Singh, and S. Mishra, [4] in their work “Single-phase solar grid interfaced system with active filtering using adaptive linear combiner filter-based control scheme,” deals with a control scheme for single-stage solar photovoltaic (SPV) grid-interfaced system. The voltage-source inverter (VSI) is a power electronic interface between SPV array and the grid. The VSI provides power quality features, i.e. harmonics mitigation, power factor correction and perturb and observe maximum power point tracking for single-stage SPV grid-interfaced system. The SPV array supplies active power to the non-linear load and grid through VSI, during daytime only or when SPV generation is more than the load power.

R. Pea-Alzola, D. Campos-Gaona, P. F. Ksiazek, and M. Ordonez, [1] in paper titled “DC link control filtering options for torque ripple reduction in low- power wind turbines,” states that small wind energy conversion systems (WECSs) are becoming an attractive option for distributed energy generation. WECSs use permanent-magnet synchronous generators (PMSGs) directly coupled to the wind turbine and connected to the grid through a single-phase grid-tie converter. The loading produced on the dc link is characterized by large ripple currents at twice the grid frequency. These ripple currents are reflected through the dc bus into the PMSG, causing increased heating and ripple torque. This paper depicts the use of PMSG inverter to control the dc-link voltage. In order to avoid reflecting the ripple currents into the PMSG, the feedback dc-link voltage is passed through a filter. The Butterworth filters, notch filters, anti-resonant filter (ARF) and moving average filter (MAF) are considered.

S. Devassy and B. Singh, [2] in their work “Modified p-q theory-based control of solar PV integrated UPQC-S,” proposes a modified p-q theory-based control of solar photovoltaic array integrated unified power quality conditioner (PV-UPQC-S). The system incorporates clean energy generation along with power quality improvement thereby increasing functionality of the system. The fundamental frequency positive sequence (FFPS) components of voltage at the point of common coupling (PCC) are extracted using generalized cascaded delay signal cancellation (GCDSC) technique which is then used in p-q theory based control to estimate reference signals for the PV-UPQC-S.

B. Singh, C. Jain, S. Goel, A. Chandra, and K. Al-Haddad,[7] in their work “A multifunctional grid-tied solar energy conversion system with anf-based control approach,” presents a two stage three-phase grid-interfaced solar

photovoltaic energy conversion system with an adaptive notch filter based control algorithm that consists of a multifunction grid-interfaced SPV energy conversion system, which along with the conversion of dc-power from SPV to ac mains is capable of reactive power compensation, harmonics currents elimination, and load balancing in a three-phase ac distribution system. Compared with multiple devices with different functionalities, a multifunction grid-interfaced SPV energy conversion system is capable of saving substantially capital investment, space, and maintenance cost on behalf of multifunctional features.

A. Parchure, S. J. Tyler, M. A. Peskin, K. Rahimi, R. P. Broadwater, and M. Dilek,[5] in their paper titled **“Investigating PV generation induced voltage volatility for customers sharing a distribution service transformer,”** discusses that the number of grid-connected rooftop solar photovoltaic systems is expected to increase significantly in the next few years. Many studies have been conducted on analyzing transmission level voltage stability with high PV penetration, and recent efforts have also analyzed voltage stability at the medium and low voltage distribution levels. However, those studies have not considered detailed distribution secondary modeling extending from the primary feeder to the service transformer and all the way through the distribution secondary connections and service drops.

A. R. Malekpour, A. Pahwa, A. Malekpour, and B. Natarajan,[6] in their paper titled **“Hierarchical architecture for integration of rooftop PV in smart distribution systems,”** deals with the design and performance analysis of a three-phase single stage solar photovoltaic integrated unified power quality conditioner (PV-UPQC). The PV-UPQC consists of a shunt and series connected voltage compensators connected back to back with common DC-link. The shunt compensator performs the dual function of extracting power from PV array apart from compensating for load current harmonics. An improved synchronous reference frame control based on moving average filter is used for extraction of load active current component for improved performance of the PVUPQC.

Y. Yang, P. Enjeti, F. Blaabjerg, and H. Wang,[10] in their review paper titled **“Wide-scale adoption of photovoltaic energy: Grid code modifications are explored in the distribution grid,”** have stated that the relative share of renewable energy, specifically the solar photovoltaic, is increasing exponentially in the world electric energy sector. This is a cumulative result of reduction in the cost of solar panels, improvement in the panel efficiency, and advancement in the associated power electronics. Among different types of PV plants, installation of small-scale rooftop PV is growing rapidly due to direct end-user benefits and lucrative governmental incentives. There are various standards developed in regards to grid integration of PVs and other distributed generations (DGs).

A. Javadi, A. Hamadi, L. Woodward, and K. Al-Haddad,[8] in their paper **“Experimental investigation on a hybrid series active power compensator to improve power quality of typical households,”** have implemented a transformer less hybrid series active filter using a sliding-mode control algorithm and a notch harmonic detection technique on a single-phase distribution feeder which provides compensation for source current harmonics coming from a voltage fed type of nonlinear load (VSC) and reactive power regulation of a residential consumer. The realized active power filter enhances the power quality while cleaning the point of common coupling (PCC) from possible voltage distortions, sags, and swells initiated through the grid.

E. Yao, P. Samadi, V. W. S. Wong, and R. Schober, [9] in their paper titled **“Residential demand side management under high penetration of rooftop photovoltaic units,”** have stated that in a residential area where many households have installed rooftop photovoltaic (PV) units, there is a reverse power flow from the households to the substation when the power generation from PV units is larger than the aggregate load of the households. This reverse power flow causes the voltage rise problem. This paper showcases the use of demand side management to mitigate the voltage rise problem by proposing an autonomous energy consumption scheduling algorithm, which schedules the operation of deferrable loads to jointly shave the peak load and reduce the reverse power flow.

3. PROPOSED METHODOLOGY

Researchers have spent a lot of time and energy over the years looking for practical uses for UPQC and strategies to boost its effectiveness. UPFC functions best in a perfectly stable and distortion-free transmission system, allowing for optimal shunt/series correction. In comparison, UPQC must function in a setting where DC components, voltage harmonics, and current harmonics all contribute to imbalances and distortions. The primary goal of the UPQC is to limit the active power in circulation by lowering the active power injected through series and shunt APFs. PVA is linked to the DC connection and helps the UPQC inject active and reactive power into the grid. Feedback from the source and load voltages and currents will be used to construct separate controllers for shunt and series converters. The sinusoidal PWM approach used by the SRF controller keeps both converters in step with the input voltage. In order to minimise power loss across the distribution system, several algorithms will be used to pinpoint where exactly the UPQC should be implemented.

4. CONCLUSION

The Unified Power Quality Conditioner (UPQC) is one of the promising power electronic circuit modules for tackling voltage sag and total harmonic distortion concerns due to its design incorporating both series active and shunt-active power filters. The majority of power quality conditioner control strategies have had their efficacy and viability examined. This study demonstrates the recent widespread interest in UPQC and associated control methods. This is due to the declining cost of computer gear (such as microcontrollers and DSPs) and the general distribution of suitable power-switching technology. The UPQC allows for the integration of RES into the present power grid while compensating for supply voltage and load current power quality concerns. This paper offers statistics that may be helpful to academics, manufacturers, and utilities doing power system analysis in addition to background information on the UPQC.

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