

Review on Design of Improved Unified Power Quality Conditioner for Power Quality Improvement

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Abstract

Non-linear loads are frequently affected by power quality (PQ). Resonance mechanisms, condenser overheating, and other performance-degrading consequences are all caused by harmonic currents. Voltage sags are common in low-voltage systems. While harmonic currents are pumped into the grid, equipment like electrical converters improve the entire response of an equal load. The necessity for reactive power is well-known for lowering feeder voltage and increasing losses. Harmonic currents can cause a poor signal by distorting the waveform voltage. There's also a rise in the number of loads that need significant sinus tension to work correctly. People are getting more interested in power conditioning solutions as electronic devices become more power-sensitive. As a result, if the amount of electricity produced falls below a specified threshold, compensation must be supplied. The Unified Power Quality Controller (UPQC) is a type of AC transmission system that can manage voltage, impedance, and phase angle. UPQC (United Provinces and Territories (FACTS). A Dynamic Voltage Restorer, a Fuzzy Controlled Shunt Active Power Filter, and a UPQC are required to improve the power quality of the power system. DVRs (Dynamic Voltage Restorers) are power converters that are installed in responsive load arrays to protect against supply disruptions. Because of its short response time and high level of dependability, it is an excellent tool for increasing the quality of electrical power. The simulation results were compared to the basic system and enhanced to demonstrate the efficiency of the suggested system.

Keywords: UPQC, FUZZY LOGIC, THD, SAG, SWELL, HARMONICS

1. INTRODUCTION

Because of the widespread use of frequency and variable speed drives, we demand robot systems, automated manufacturing lines, precise digital control systems, programmable logic control systems, computer data management systems, and so on. In these buildings and gadgets, there is a lot of vulnerability to wave power and other anomalies. Non-linear loads and harmonic sources are found in many of these devices. Power quality

issues could have a negative influence on product quality and management confidence.

Consumer awareness of power quality issues has increased dramatically in recent years. Most consumers did not perceive disruptions that lasted less than a few minutes to be a problem. Customer expectations are rising, which needs a greater focus on power quality. Poor-quality electricity has a big impact on a lot of people.

A lack of quality power can have a significant influence on people's health, as well as a reduction in production and damage to machines and equipment. As a result, maintaining a high level of power efficiency is crucial. There are traditional solutions to power quality issues. On the other hand, traditional systems rely on passive components that may or may not react to changing power supply conditions. Because of the increased capacity, control, and cost-cutting capabilities of today's semiconductor technology, a wide range of applications are now possible. Thanks to these power converter devices, a range of power quality issues can now be addressed in novel and creative ways. Non-linear equipment, such as electrical converters, convert the distribution grid into harmonic currents, increasing the total reactive power required by equivalent load. As a result of the increased demand for sensitive power, the feeder's voltage declines and its loss increases. Harmonic currents, which produce extra losses and voltage distortion, can degrade energy quality. In addition, the number of delicate loads that require optimal sinusoidal tension to work properly has increased. The growing use of responsive power in electronic devices is a driving force in the field of power technology. To keep the power's efficiency within acceptable limits, some form of correction is also required. Customers' power quality can be improved by using power electronic energy-conditioning systems. Efficiency is raised, size is lowered, and control is improved with the power electronic transition. Switching operations in such systems produce non-linear loads. When these systems are connected to the benefits, they draw a trailing current from the source. As a result, these structures are warped and misshapen. As a result, power networks function as large reactive voltage amplifiers into which harmonics are introduced. When voltage drops occur in an industrial context, workers can be hurt, waste material is created, and the system must be restarted for long periods of time. As a result of system failures, faults,

expensive maintenance, and exorbitant service costs, low manufacturing quality might result in lost sales and/or contract fines. Expenses in high-volume industries like semiconductors, autos, and chemicals can quickly reach millions of dollars.

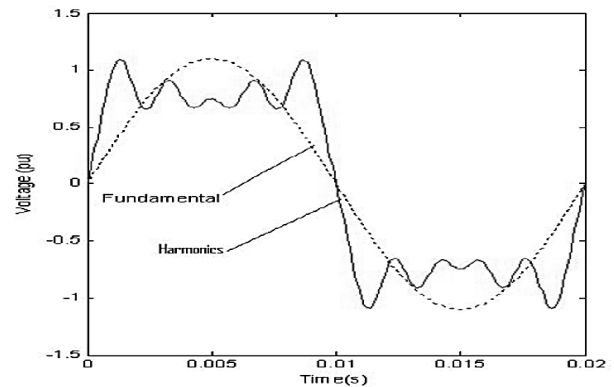


Figure. 1 Voltage Waveform Showing Harmonics

Industrial automation has reached previously unheard-of levels of complexity. To support the various complex technologies currently housed in facilities, such as vehicle production factories and chemical manufacturing plants, a large public grid is required. On the other side, the grid has the ability to stray and disrupt in unanticipated ways. A power quality device, such as a DVR system or a SAPF, must be utilised if this network contains a sensitive charge to provide a rock-solid, clean, and uninterrupted supply of power to the charge. The device appears promising to researchers for use in the transportation and distribution industries, thanks to advancements in semiconductor technology at higher voltage levels.

2. UNIFIED POWER QUALITY CONDITIONER

UPQC is also known as a universal power quality conditioning system, an active power line conditioner, or an active filter. To enable active power sharing via a shared DC link capacitor, the UPQC combines a shunt (Active Power Filter) and a series compensator (Dynamic Voltage Restorer) (Aredes et al. 1998). Both the distribution network

operator and the end consumer can address power quality concerns in a variety of ways. As a result of the multiple benefits given by power electronic devices, power processing at the supply, load, and for reactive and harmonic compensation is becoming more widespread (Singh et al. 1999). The primary advantage of UPQC is that it does not require energy storage. It can be configured to attenuate any sag that reaches a specific magnitude, regardless of duration. This could lead to a device that competes with the uninterruptible power supply (UPS), which is routinely used to protect low-power and low-voltage electronic devices. UPQC is far more adaptable than DSTATCOM, which is suited to the needs of each individual (Kolhatkar et al. 2007). UPQC topologies include multilevel topology, single-phase UPQC with two half-bridge converters, single-phase UPQC with three legs, and H bridge topology (Ghosh et al. 2004). UPQC is typically used to alter the voltage across a sensitive load on one feeder while also adjusting the bus voltage on the other. Instantaneous reactive power theory is widely used to compute reference currents for shunt converters, and the multi converter universal power quality conditioner (MC-UPQC) is a new design being developed to compensate voltage and current in neighbouring feeds at the same time (Khadkikar et al. 2012). (Fujita et al. 1998). To suppress harmonics and correct the power factor, an extended technique based on instantaneous reactive power theory in a rotating reference frame is applied. In this paper, an adaptive detection technique is investigated that reduces the impact of noise or parameter changes (Karimi et al. 2003). To generate reference signals for series converters, fuzzy control (Singh et al. 1999), finite impulse response filtering (Chen et al. 2004), band pass filtering and positive sequence calculation, dq transform, vector template generation method (Khadkikar et al. 2011), sinusoidal template vector algorithm, PI controller method (Basu et al. 2008),

and adaptive detection method (Rong et al. 2009) are used.

To produce gating signals for a single shunt converter, a predictive current regulation and hysteresis controller are used (Basu et al. 2008). To generate gating signals for just series converters, sinusoidal PWM (Basu et al. 2008) and hysteresis controller (Khadkikar et al. 2004) approaches are used. For both series and shunt side inverter signal generation, space vector PWM, fuzzy hysteresis control, and SPWM approaches are favoured (Lee et al. 2010).

To keep UPQC's overall power balance, DC-link capacitors are used (Jayanti et al. 2009). Traditional DC voltage feedback or PI control (Basu et al. 2008) or composite control can be used to control DC voltage (Basu et al. 2008). (Salam and colleagues, 2006). Whether the UPQC model is right shunt-UPQC or left shunt-UPQC is determined by the location of the shunt compensator in relation to the series compensator. The active power generated in one unit is consumed in the other, according to Ghosh et al. 2002) [40]. This ensures energy balance. The overall properties of the right shunt-UPQC are superior than those of the left shunt-UPQC.

The protection of a UPQC against voltage surges and short circuit scenarios is discussed in detail to avoid malfunction or damage (Zhilli et al. 2010). The power circuit of UPQC consists of a common energy storage unit, a DC/AC converter, a low-pass filter, and an injection transformer. The use of an inverter and line side filtering can reduce the impact of harmonics emitted by the inverter. For both series and shunt sides, inverter side LC filtering is typically used (Basu et al. 2008), but inverter side L filtering is generally preferred for both series and shunt sides (Axente et al. 2010). UPQC can be used in both medium and low voltage applications. Because VR spends the majority of its time in standby mode, installing UPQC in low-

power applications is difficult. In UPQC systems, three-phase, three-wire (3P3W) systems are often employed. By employing the neutral of the series transformer used in the UPQC series component as the fourth wire, three-phase four-wire (3P4W) systems can be created from three-phase three-wire (3P3W) systems (Khadkikar et al. 2009). The UPQC Custom Power device incorporates a series active power filter for voltage harmonics, voltage unbalance, voltage flicker, and voltage sag/swell compensation, as well as a shunt active power filter for current harmonics, current unbalance, and reactive current compensation (Khadkikar et al. 2011). Because the UPQC series converter spends the majority of its time in standby mode, conduction losses account for the majority of converter losses during operation. The series injection transformer acts as a secondary shorted current transformer in this mode, with bypass switches sending utility power to the load directly. In the building of UPQC, the injection transformer was not employed (Basu et al. 2002). The paper describes a revolutionary UPQC design that does not require series injection transformers to connect to the distribution grid (Han et al. 2006).

Shunt active power filters are typically connected across loads to address all current-related issues such as reactive power compensation, power factor improvement, current harmonic compensation, and load unbalance compensation, whereas series active power filters are connected in series with a line via a series transformer to address all current-related issues such as reactive power compensation, power factor improvement, current harmonic compensation, and load unbalance compensation. It functions as a controlled voltage source that can correct for voltage harmonics, voltage sag, voltage swell, and flicker (Khadkikar et al. 2008)[42]. The shunt component facilitates in the rectification of energy quality concerns caused by users. This includes low-power loads, harmonic loads, load imbalances, and DC offset, to name a

few. On the dc side, the UPQC's shunt section consists of a voltage source inverter (VSI) coupled to a shared DC storage condenser, and on the shunt side, an inductor and shunt link transformer. The VSI shunting frequency harmonics are filtered out using the shunt interface induction and the shunt filter condenser. The shunt link transformer balances the network and VSI voltages.

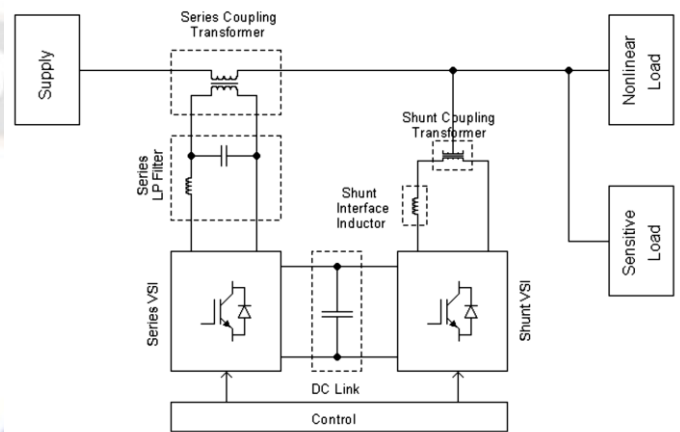


Figure 1. UPQC single line diagram

The shunt active filter, which cancels the reactive and harmonic components of charge currents and reduces load current unbalance, is the common connecting point of the compensation circuit. To inject current into the circuit, the dc storage condenser and the Shunt VSI are utilised. Based on projected currents and voltages, the control system generates the necessary switching signals for the VSI Shunt switches. The control approach used has an impact on the genuine currents and voltages calculated. Furthermore, the VSI-connected series process makes advantage of the shunt system as the true power flow conduit. Furthermore, the DC storage condenser maintains a constant average voltage. The VSI shunt is controlled in the current control mode. To monitor the injected currents from the shunt active filter in a specified hysteresis band, the necessary VSI switches are turned on and off from time to time (assuming that the hysteresis controller is issued).

The VSI controls whether the dc condenser is turned on positively or negatively. When the dc condenser tension is positive, the supply voltage is applied, causing the VSI current to rise. Because the voltage is the inverse of the supply voltage, the VSI current is reduced when a negative DC capacitor is used. As a result, the reference current alternates between increasing and dropping within the hysteresis zone. This procedure is known as "Unit Control for Hysteresis." The dc side condenser has two purposes: it maintains a stable dc voltage with minimum ripple, and it acts as an energy storage device during the transient cycle by supplying a true power difference between the load and the source. The average voltage across the dc condenser must be maintained at or above the maximum voltage to allow the shunt active filter to draw leading electricity. The active current drawn by the device's shunt active filter is controlled by a proportional integer control. Supply-side disturbances such as voltage swells, flutters, voltage imbalances, and harmonics are maintained to a minimum by the UPQC's series section. It boosts the load voltages to keep them balanced, distortion-free, and at the correct level. On the dc side, the UPQC series includes a VSI coupled to the same power condenser, as well as a series of low pass filters (LPF) and coupling transformers. Because of the LPF series, the VSI series is not included in the switching frequency harmonics scheme. The transformers in series provide the network's voltage and isolation, as well as the VSI. By integrating serial and supply voltages, series active filter compensation achieves its aims of aligning and maintaining load voltages at the desired level. The voltage is injected using a dc storage condenser and the VSI series. Based on the calculated supply and/or load voltages, the control technique generates the necessary switching signals for the VSI switches. In voltage-control mode, the VSI series is driven by the widely used modular pulse-width switching technology. The needed signal is compared to a triangle waveform

signal with a higher frequency, and enough switching signals are generated to supply the voltage injection with the desired magnitude, waveform, phase shift, and frequency. The dc condenser is connected to the inverter outputs with positive and negative polarity. Although there are no desired signals in the series VSI's output voltages, switching harmonics do exist and are filtered out by the system's low-pass filter. The amplitude, phase shift, frequency, and harmonic content of the injected voltages are all controlled.

3. PROPOSED METHODOLOGY

UPQC performance is influenced by the design of power semiconductor systems, the modulation technique employed, the design of coupling components, the method used to determine the active filter current and tension references, and the dynamics and robustness of current and tension control loops. For fluctuating hysteresis, we describe band voltage and current control techniques in which the system parameters modulate the band to a nearly constant modulation frequency. The FLC compensation method successfully removes harmonic voltage and current sizes while keeping a high dynamic response. The UPQC is an active power filter that uses a common direct current connection to connect the shunt and serial series. Harmonic voltage, voltage imbalance, voltage flickerings, voltage drops, voltage swells, current harmonics, current imbalance, and reactive current can all be fixed. UPQC's ability to attenuate voltage slopes and swells has recently earned a lot of press. In all operational conditions, the goal is to maintain a constant sinusoidal load bus voltage. In distribution networks, one type of UPQC structure is shown in Figure 2. Active power filtering has proven to be one of the most effective approaches for addressing serious power quality issues. The APF shunt solves all current problems, including current harmonics, reactive current, and current imbalance. The APF series, on the other hand,

addresses all voltage concerns, including harmonics, voltage sags, swelling, and voltage unbalance.

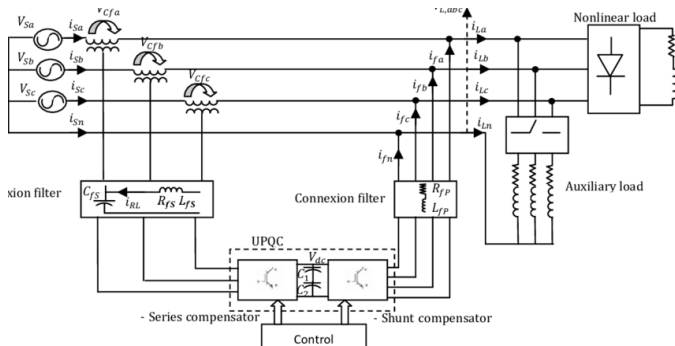


Figure 2. Unified power conditioner based on Fuzzy logic

The UPQC is set up so that the cargo bus is always the proper size and has a sinusoidal voltage. Because the voltage supplied differs from the optimum charging voltage, the voltage injected through the APF series should be equivalent. As a result, the APF series is a voltage source with a regulated output. Shunt APFs are used to keep the dc connection voltage constant forever. A load-based VAR is also included in the shunt APF, ensuring that the input power factor is uniform and that the source is the only source of essential active power. The efficiency of an active power filter is influenced by the current controller's design parameters, the manufacturing process for the reference template, and the modulation technique used. Using the shunt active power filter management approach, the current reference shape is identified, a constant dc voltage is maintained throughout each inverter step, and inverter gating signals are generated. An active power filter's compensation efficiency is also dependent on its ability to match the measured reference signal with the least amount of error and time delay in order to compensate for the distorted load present. Indirect and direct control are the two types of control, with the latter being more common. A series inverter controls a non-sinusoidal voltage source, while a shunt inverter controls a non-sinusoidal current

source. On the grid, voltage distortion and fundamental power variation must be identified. By regulating serial inverter voltages that are in conflict with directives, these voltage controls ensure that the load voltage is sinusoidal. It's also critical to identify load reactive and harmonic currents. These values drive the shunt inverter, which generates compensatory currents that oppose the orders, ensuring that the grid's input power is sinusoidal and the power factor is unitary.

Direct control governs the inverter, which delivers sinusoidal current and voltage. The power supply is unitary to maintain the electric power grid's power supply current, and the output load voltage is sinusoidal. The series inverter protects the grid from load voltage variations, whereas the shunt inverter protects the grid from reactive energy, harmonic load currents, and the neutral current. When the grid is shut off or recovered, PWM controlled inverters are also more efficient in controlling asymmetry, particularly imbalanced failures over current. Three single-phase PWM VSIs are employed in this control technique. The DVR power circuit's single phase H-bridge PWM inverters can inject positive, negative, and non-sequence voltages. The voltage is regulated by modulating the output voltage waveform with an inverter. The main advantage of the PWM inverter is that the power switches operate at a high rate of speed. PWM technology combines speed and ease of use. High switching frequencies can also be used to boost the converter's efficiency without creating significant switching loss. [21].

4. CONCLUSIONS

Voltage slopes and current harmonics are the most common power quality issues among commercial and industrial utility users. These power quality issues can be caused by sensitive electronic equipment, erratic installation processes, and significant cost losses. Custom control devices have piqued interest for more than a decade as a

way to improve the efficiency and quality of power delivered to electricity users. UPQC is a control system that consists of two inverters connected by a DC standard and may perform APF and DVR operations at the same time. The primary goal of this study was to develop UPQC control algorithms for better performance. The UPQC, on the other hand, does not provide varied levels of power to its consumers because it exclusively addresses concerns with end-user power quality. An instantaneous symmetrical component theory is simple to construct and provides a reasonable dynamic response. The control strategy generates a reference compensating sequence active filter voltages and a reference compensating shunting active filter currents, causing the source and load side currents and voltages to become sinusoidal and equilibrated under various power quality conditions. The neutral current is essentially offset since it can flow to the neutral transformer point at absolute zero potential. Based on the instantaneous active and reactive power theory, an appropriate mathematical model of UPQC has been developed. The UPQC controller was created using a zero transforming and effectively positive sequence detecting instantaneous power system. This control technique is used to evaluate harmonic identification, reactive power compensation, and effects.

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