POWER QUALITY ENHANCEMENT BY UNIFIED POWER QUALITY CONDITIONING SYSTEM WITH STORAGE DEVICE

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ABSTRACT: This paper presents a new concept of co-ordinated active power sharing between shunt and series converters of unified power quality conditioner (UPQC) for distributed generation applications with PID controller. Normally, the UPQCs are used to mitigate both voltage and current power quality problems. However, these UPQCs are also used for delivering active power in addition to its power quality improvement by integrating distributed generation (DG) at the DC link of back to back connected converters. But, only the shunt converters are used to carry the whole active power from the DG sources and the series converters are used to handle only voltage related power quality problems. So, the shunt converter is loaded heavily and the series converter is kept idle in steady state cases. The more dependency on the shunt converter also reduces the reliability of the total system. This proposed control strategy is used to carry active power through both series converter and shunt converter even at the steady state conditions. The proposed method improves the utilization of the converters and also the reliability of the system. The effectiveness of the proposed control strategy is demonstrated by comparing with the conventional control algorithm, where only the shunt converter is used to carry active power.

Keywords—Distributed Generation; unified power quality control (UPQC); PID Controller

I. INTRODUCTION

The challenging issues of a successful placement and integration of unified power quality conditioner (UPQC) in a distributed generation (DG)-based grid connected microgrid (μG)system are 1) Control complexity for active power transfer; 2) ability to compensate non-active power during the islanded mode; and 3)difficulty in the capacity embellishment in a modular way [1].For a smooth power transfer between the grid-connected system and islanded mode, various operational changes are presented, such as switching between the current and voltage control mode, robustness against the islanding detection and re connection delays and method and so on [2], [4]. Clearly, these further increase the control complexity of the microgrid systems. To extend the operational flexibility and to improve the powerquality in grid connected microgrid systems, a new control strategy placement and integration technique of UPQC have been proposed in [3], which is termed as UPQC μG.In the UPQC μG integrated distributed system, micro grid (with storage) and shunt part of the UPQC μG are placed at the Point of common coupling. The series of the UPQC is placed before the Point of common coupling and in series with the grid. DC link is connected to the storage also, if present.

In this paper, the control technique of the presented UPQC μG and PID controller in [4] is enhanced hence; it is termed as UPQC μG−IR. The benefits offered by the proposed UPQC μG−IR over the conventional UPQC are as follows .To observe the effect on the characteristic of voltage sag / swell and interruption for the techniques. Both in the interconnected and islanded modes, the μG provide only the active power to the load. Therefore, it can reduce the control complexity of the DG converters. Islanding detection and reconnection technique are introduced in the proposed UPQC as a secondary control. To maintain the operation in islanded mode and reconnection through the UPQC and PID, communication process between the UPQC μG and μG system is mentioned in [5]. In this paper, thecontrol technique of the presented UPQC μG and PID controller in[6] is enhanced by implementing an intelligent islanding and novel re connection technique with reduced number of switches that will ensure seamless operation of the μG without interruption [7].Hence, it is termed as UPQC μG−IR. The benefits offered bythe proposed UPQC μG−IR over the conventional UPQC areas follows.

- It can compensate voltage interruption/sag/swell and non-active current in the interconnected mode.
- Therefore, the DG converter can still be connected to the system during these distorted conditions. Thus, it enhances the operational flexibility of the DG converters/μG system to a great extent, which is furtherelaborated in later section.
- Shunt part of the UPQC Active Power Filter (APFsh) can maintain connection during the islanded mode and also compensates the non-active Reactive and HarmonicPower (QH) power of the load.

- Both in the interconnected and islanded modes, the μG provides only the active power to the load. Therefore, it can reduce the control complexity of the DG converters.
- Islanding detection and reconnection technique areintroduced in the proposed UPQC as a secondary control. A communication between the UPQC and μG is also provided in the secondary control. The DG converters may not require having islanding detection and reconnection features in their control system [8-12].

Fig.1 shows the system configuration of the UPQC integrated with the distributed generation (DG) at the DC link of back to back connected converters. This distributed energy resource may consists of different renewable sources e.g., solar, wind, biogas and fuel cell in conjunction with ultra-capacitor as energy storage system. However, in the present case only ultra-capacitor is considered for demonstration purpose. The mainpurpose of the UPQC is to transfer the power generated from the DG to the load and also to improve the voltage and current power quality problems.

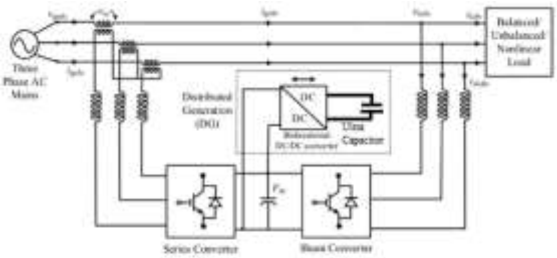

Fig 1 configuration of UPQC with DG

II. CONVENTIONAL CONTROL STRATEGY:

UPQC The schematic block diagram of conventional UPQC-Q is shown in the Fig.2. The UPQC consists of two 3-phase voltage source inverters connected in cascade through a common DC link capacitor. The DVR and the STATCOM are series and shunt connected voltage source inverters (VSIs) respectively. The main objectives of STATCOM are to compensate for the reactive power demanded by the load, to eliminate the harmonics from the supply current, and to regulate the DC link voltage. The STATCOM operates with hysteresis current control mode to force the source current, is, in phase with V_s such that input power factor is always maintained unity.

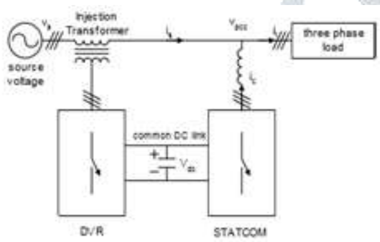

Fig.2 Block diagram of UPQC

To minimize voltage harmonics and to balance and control, the terminal voltage of the load or line, using a series transformer series AF is connected in series with the mains before the load. It is used to reduce negative-sequence voltage and control the voltage on three-phase systems. It can be installed by electric utilities to damp out harmonic propagation caused by resonance with line impedances and passive shunt compensators and to compensate voltage harmonics.

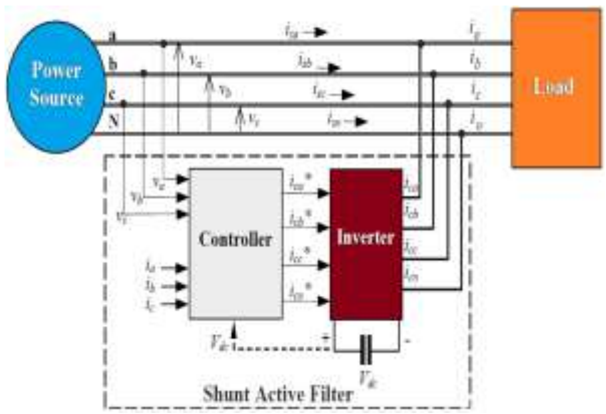

Fig. 1.1 shunt connected active filter

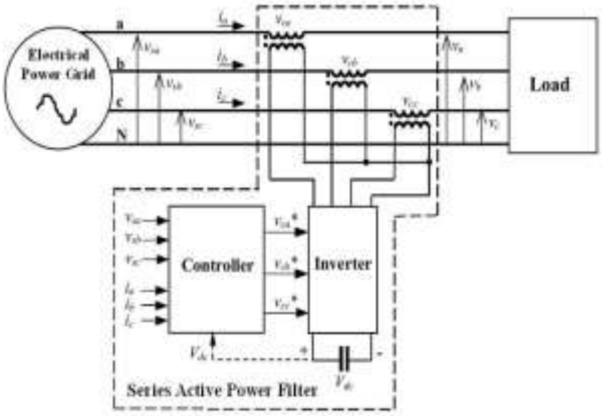

Fig. 1.2 series connected active filter

III. PROPOSEDCONTROL STRATEGY:

This section presents the proposed control algorithms forseries converter, shunt converter, and battery energy storagesystem (BESS). The main objective of this UPQC is to transferactive power from the DG and also to improve the voltage andcurrent power quality problems.

A. *Series Converter control algorithm*

The main purpose of the series converter is to improve thevoltage power quality and also to transfer active power. Thevoltage power quality problems are eliminated by injecting thevoltage in series through series transformer. The active poweris transferred through the series transformer by phase shiftingthe load voltage from the grid voltage. So, the reference loadvoltage is generated in such a way to inject active power andalso to improve the voltage power quality at the load terminals. The phasor diagram for the basic understanding of seriesconverter voltage injection scheme is shown in Fig.3. Thecontrol schematic for the series converter is presented in Fig.3.The maximum active power that can be transferred through theseries converter depends upon the kVA rating of the converter.

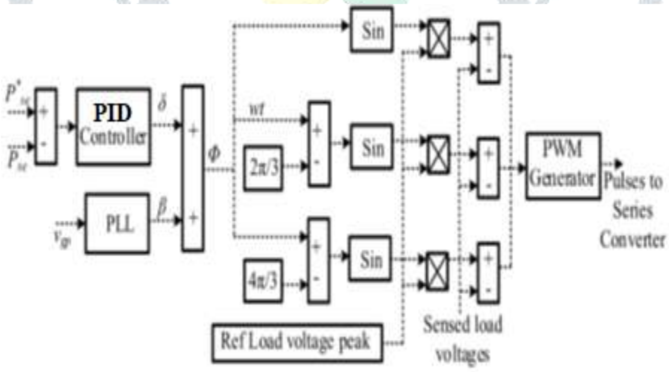

Fig. 3 Control algorithm for the series converter.

B. Shunt Converter Control Algorithm

A shunt active filter is used to transfer the active powerfrom the DG in addition to the basic responsibilities such asload current harmonics compensation and load reactive powercompensation. So, the shunt converter current consists of loadcurrent harmonics, the reactive component of load current andactive power component of shunt converter current. However, indirect current control method is adapted for controlling theshunt converter. So, the grid currents are taken as reference, which should be free from harmonics. The complete controlscheme for the shunt converter is presented in Fig.4.

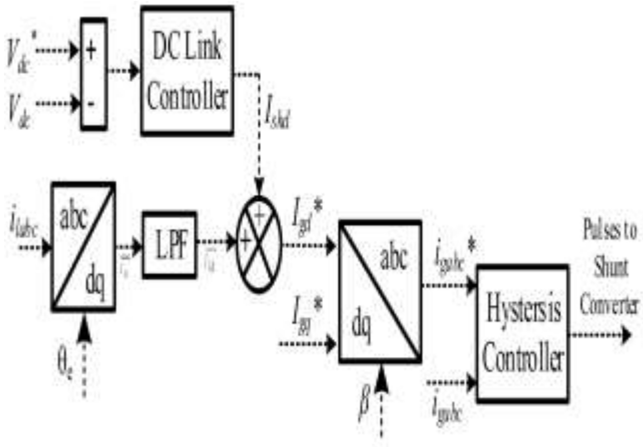

Fig.4. Control algorithm for shunt converter.

IV. MATLAB AND SIMULATION RESULTS:

The Simulation block diagram is shown in figure.5.

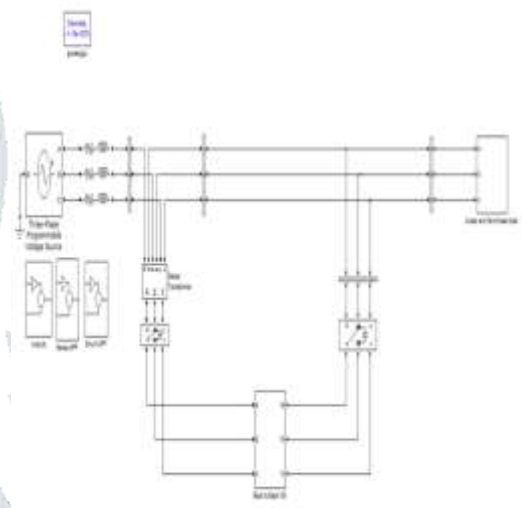

Fig.5. MATLAB Simlink block diagram

Case 1: Output Voltage waveforms are under sag conditions is shown in figure.6.

Fig.6. a) Source Voltage b) Load Voltage c) Injected Voltage d) Ultra capacitor capacitance.

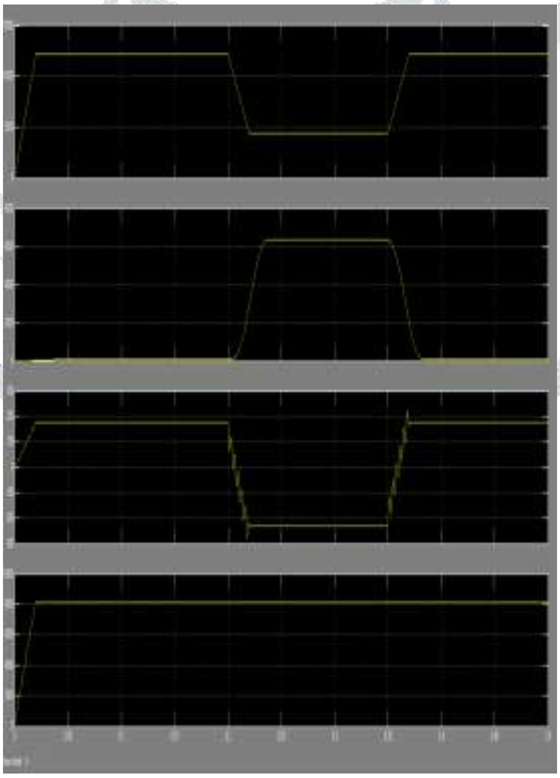

Fig.7. a) Source power b) Injected power c) Ultra capacitor power d) load power.

When there is a sag in the system the UPQC detects it and with the help of storage device it generates voltage i.e it injects the required voltage into the system with the help of series converter and maintains the voltage. Which improves the reliabilty and power quality of the system under voltage sag conditions.

Case 2: Output Voltage waveforms are under swell conditions is shown in figure.8 and power waveforms are shown in figure.9

When there is a swell in the system the UPQC detects it and observes the extra voltage from the system with the help of shunt converter and maintains the voltage. Which improves the reliabilty and power quality of the system under voltage swell conditions.

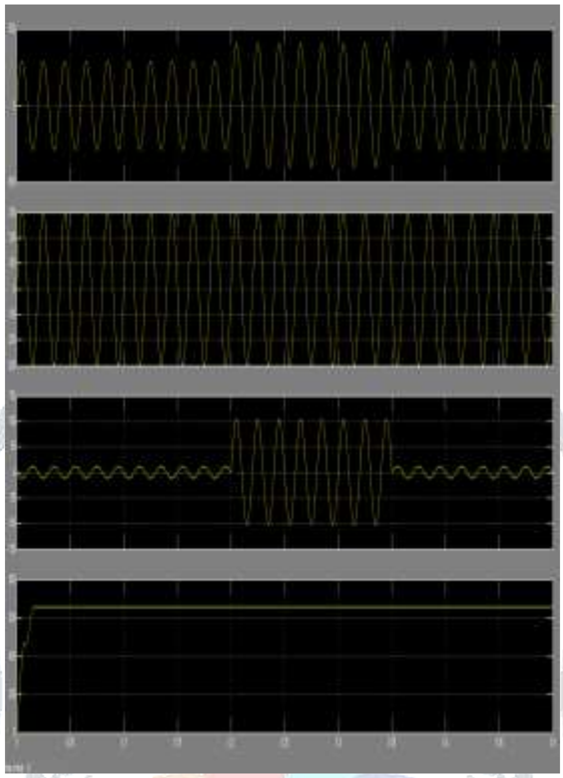

Fig.8. a) Source Voltage b) Load Voltage c) observed Voltage d) Ultra capacitor capacitance.

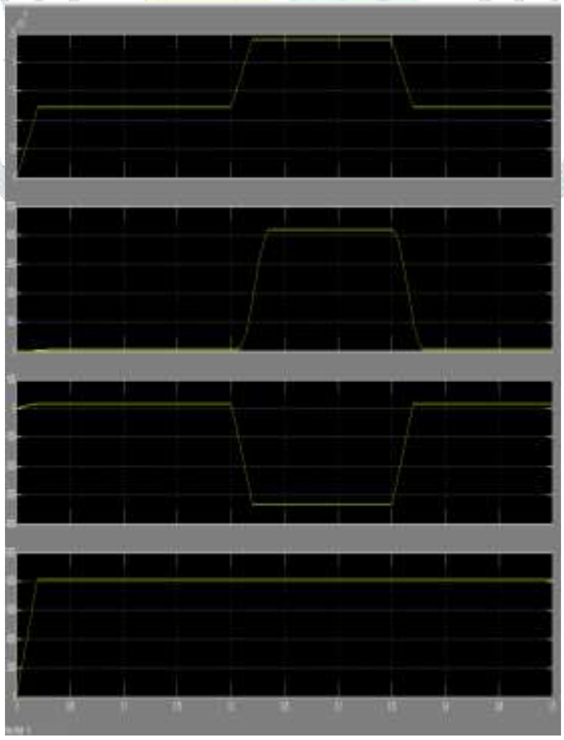

Fig.9. a) Source power b) observer power c) Ultra capacitor power d) load power.

V. CONCLUSION:A new coordinated active power control strategy has beenproposed to share the active power between the shunt andseries converters of the UPQC for distributed generationapplications. This proposed control strategy has beencompared with the conventional control strategy of the UPQC. This controlalgorithm reduces the burden on the shunt converter and alsoimproves the reliability of the system.

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