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Power Quality Improvement Using Unified Power Quality Conditioner (UPQC)

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***Abstract*— This paper presents a comprehensive review on the unified power quality conditioner (UPQC) to enhance the electric power quality at distribution levels. Unified power quality conditioners (UPQCs) allow the mitigation of voltage and current disturbances that could affect sensitive electrical loads while compensating the load reactive power. The shunt and series active filter performs the simultaneous elimination of current and voltage problems. The power fed is linked through common DC link and maintains constant real power exchange. The DC link is connected through the reactor. The real power supply is given by the photovoltaic system for the compensation of power quality problems. The reference current and voltage generation for shunt and series converter is based on phase locked loop and synchronous reference frame theory.**

***Index Terms*— Active power filter (APF), harmonic compensation, power quality, reactive power compensation, unified power quality conditioner (UPQC), voltage sag and swell compensation.**

I. INTRODUCTION

Unified power quality conditioners (UPQCs) consist of combined series and shunt active power filters (APFs) for simultaneous compensation of voltage and current disturbances and reactive power. They are applicable to power distribution systems, being connected at the point of common coupling (PCC) of loads that generate harmonic currents. In general, poor power quality may result into increased power losses, abnormal and undesirable behavior of equipment, interference with nearby communication lines, and so forth. The widespread use of power electronic based systems has further put the burden on power system by generating harmonics in voltages and currents along with increased reactive current. The term active power filter (APF) is a widely used terminology in the area of electric power quality improvement. The series APF must compensate the source voltage disturbances, such as harmonics, dips or over-voltages, which might deteriorate the operation of the local load while the shunt APF attenuates the undesirable load current components (harmonic currents and the fundamental frequency component which contributes to the reactive load power). Moreover, the shunt APF must control the dc-bus voltage in order to ensure the compensation capability of the UPQC. These functionalities can be carried out by applying diverse control strategies which can operate in the time domain, in the frequency domain or both. Time domain methods, such as pq or dq based methods allow the fast compensation of time-variant disturbances but make more complex their selective compensation. In this sense, frequency domain methods are more flexible but their dynamical response is slower.

II.POWER QUALITY

Power Quality (PQ) related issues are of most concern nowadays. The widespread use of electronic equipment, such as information technology equipment, power electronics such as adjustable speed drives (ASD), programmable logic controllers (PLC), energy-efficient lighting, led to a complete change of electric loads nature. These loads are simultaneously the major causers and the major victims of power quality problems. Due to their non-linearity, all these loads cause disturbances in the voltage waveform. Along with technology advance, the organization of the worldwide economy has evolved towards globalization and the profit margins of many activities tend to decrease. The increased sensitivity of the vast majority of processes (industrial, services and even residential) to PQ problems turns the availability of electric power with quality a crucial factor for competitiveness in every activity sector. The most critical areas are the continuous process industry and the information technology service. When a disturbance occurs, huge financial losses may happen, with the consequent loss of productivity and competitiveness. Although many efforts have been taken by utilities, some consumers require a level of PQ higher than the level provided by modern electric networks. This implies that some measures must be taken in order to achieve higher levels of Power Quality.

III. UNIFIED POWER QUALITY CONDITIONER

The Unified Power Quality Conditioner is a custom power device that is employed in the distribution system to mitigate the disturbances that affect the performance of sensitive and critical load. It is a type of hybrid APF and is the only versatile device which can mitigate several power quality problems related with voltage and current simultaneously.

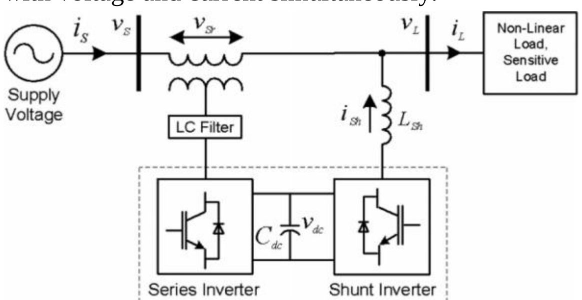

Fig 1: Hardware structure of UPQC

The main purpose of a UPQC is to compensate for supply voltage power quality issues, such as, sags, swells, unbalance, flicker, harmonics, and for load current power quality problems, such as, harmonics, unbalance, reactive current, and neutral current. The key components of this system are as follows.

1) Two inverters -one connected across the load which acts as a shunt APF and other connected in series with the line as that of series APF.

2) Shunt coupling inductor Lsh is used to interface the shunt inverter to the network. It also helps in smoothing the current wave shape. Sometimes an isolation transformer is utilized to electrically isolate the inverter from the network.

3) A common dc link that can be formed by using a capacitor or an inductor. In Fig. 1, the dc link is realized using a capacitor which interconnects the two inverters and also maintains a constant self-supporting dc bus voltage across it.

4) An LC filter that serves as a passive low-pass filter (LPF) and helps to eliminate high-frequency switching ripples on generated inverter output voltage.

5) Series injection transformer that is used to connect the series inverter in the network. A suitable turn ratio is often considered to reduce the voltage and current rating of series inverter.

IV.SYNCHRONOUS REFERENCE FRAME (SRF) THEORY

The control strategy for the unified power quality conditioner is based on the synchronous reference frame (SRF) theory. In this theory controlling of the three-phase converters using the rotating frame theory by converting the source voltage and current to direct and quadrature axis is done. The voltage is converted to dq in the series controller and current is converted to dq in the series controller. Consider the shunt converter performs the process of elimination of harmonics and series converter performs process of elimination of the voltage related problems. The control block diagram for the synchronous reference frame theory is shown in Figure 2

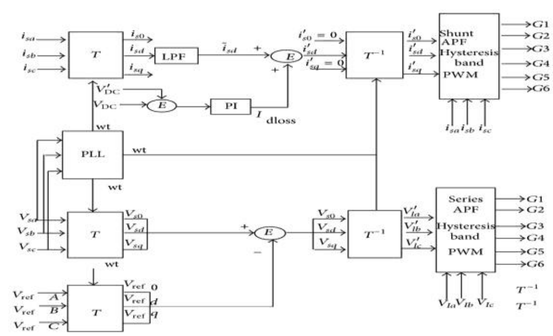

Figure-2: Control Block Diagram

V. SIMULATION RESULTS

The UPQC-CSC has the reactor as the DC link for the series and shunt converter and is controlled by the synchronous reference frame (SRF) theory and the pulse is generated by the hysteresis band controller. The shunt and series converters have the function of compensating current and voltage problems, respectively. The simulation of UPQC-CSC is shown in Figure 3. The output of UPQC-CSC is shown in Figure 4 which shows the voltage with sag, current with harmonics, and compensated voltage and current.

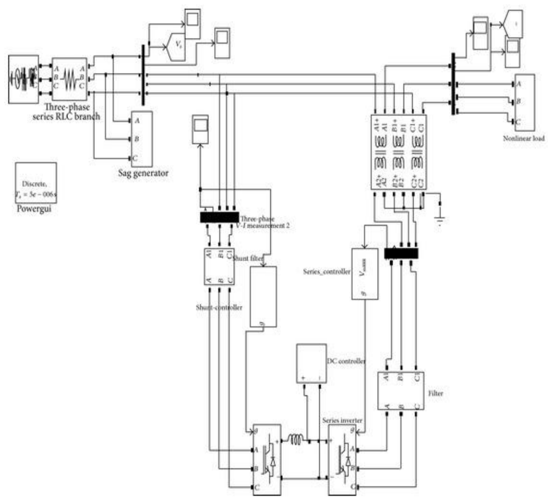

Figure-3: UPQC-CSC simulation diagram

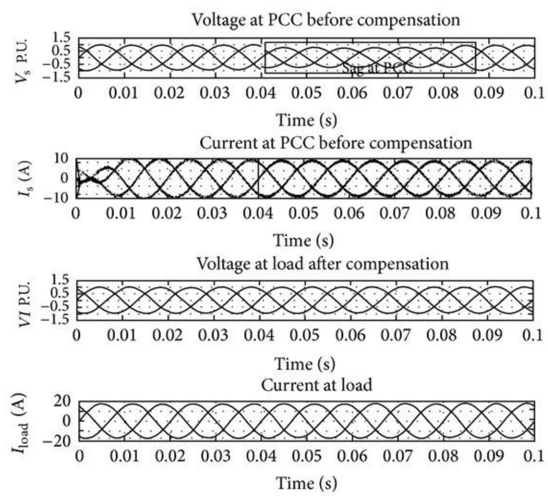

Figure-4: Output of source voltage and current and load voltage and current waveform

VI. CONCLUSION

In this paper, synchronous reference frame theory based control method is implemented to control the working of unified power quality conditioner based on current source converter topology. The simulation results show that the device is capable of compensating the current harmonics under unbalanced and nonlinear load conditions, simultaneously mitigating voltage sag and swell. The proposed UPQC-CSC design has superior performance for mitigating the power quality problems.

APPLICATIONS: Used in

1. Distribution systems,
2. Transmission systems.

ADVANTAGES: It compensate

1. Supply voltage
2. Flicker/imbalance,
3. Reactive power,
4. Negative sequence current, And Harmonics.

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