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A New Control scheme for a Dual Unified Power Quality Conditioner

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Abstract:

Power quality determines the fitness of electrical power to consumer devices. Synchronization of the voltage frequency and phase allows electrical systems to function in their intended manner without significant loss of performance or life. The term is used to describe electric power that drives an electrical load and the load's ability to function properly. Without the proper power, an electrical device (or load) may malfunction, fail prematurely or not operate at all. There are many ways in which electric power can be of poor quality and many more causes of such poor quality power. This paper presents a simplified control technique for a dual three-phase topology of a unified power quality conditioner—iUPQC. The iUPQC is composed of two active filters, a series active filter and a shunt active filter (parallel active filter), used to eliminate harmonics and unbalances.

Index Terms—Active filters, control design, power line conditioning, unified power quality conditioner (UPQC).

I. INTRODUCTION

The electric power industry comprises electricity generation (AC power), electric power transmission and ultimately electricity distribution to an electricity meter located at the premises of the end user of the electric power. The electricity then moves through the wiring system of the end user until it reaches the load. The complexity of the system to move electric energy from the point of production to the point of consumption combined with variations in weather, generation, demand and other factors provide many opportunities for the quality of supply to be compromised. Power quality is the quality of the voltage—rather than power or electric current—that is actually described by the term "Power Quality". Power is simply the flow of energy and the current demanded by a load which is largely uncontrollable.

To improve the quality of power for non-linear and voltage sensitive load, UPQC is one of the best solutions.[7].Unified Power Quality Conditioner (UPQC) consists of two IGBT based Voltage source converters (VSC), one shunt and one series cascaded by a common DC bus. The shunt converter is connected in parallel to the load. It provides VARsupport to the load and supply harmonic currents. Whenever the supply voltage undergoes sag then series converter injects suitable voltage with supply[2]. Thus UPQC improves the power quality by preventing load current harmonics and by correcting the input power factor. A unified power-quality conditioner (UPQC) can perform the functions of both DSTATCOM and DVR. The UPQC consists of two voltage source converters (VSCs) that are connected to a common dcbus. One of the VSCs is connected in series with a distribution feeder, while the other one is connected in

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shunt with the samefeeder. The dc links of both VSCs are supplied through acommon dc capacitor.

The aim of this paper is to propose a simplified controltechnique for a dual three-phase topology of a unified powerquality conditioner (iUPQC) to be used in the utility grid connection. The proposed control scheme is developed in ABCreference frame and allows the use of classical control theorywithout the need for coordinate transformers and digital controlimplementation. The references to both SAF and PAFs are sinusoidal,dispensing the harmonic extraction of the grid current and load voltage.

II. DUAL UPQC

The conventional UPQC structure is composed of a SAF and a PAF, as shown in Fig. 1. In this configuration, the SAF works as a voltage source in order to compensate the grid distortion, unbalances, and disturbances like sags, swells, and flicker. Therefore, the voltage compensated by the SAF is composed of a fundamental content and the harmonics. The PAF works as a current source, and it is responsible for compensating the unbalances, displacement, and harmonics of the load current, ensuring a sinusoidal grid current. The series filter connection to the utility grid is made through a transformer, while the shunt filter is usually connected directly to the load, mainly in low-voltage grid applications. The conventional UPQC has the following drawbacks: complex harmonic extraction of the grid voltage and the load involving complex calculations, voltage and current references with harmonic contents requiring a high bandwidth control, and the leakage inductance of the series connection transformer affecting the voltage compensation generated by the series filter. In order to minimize these drawbacks, the iUPQC is investigated in this paper, and its scheme is shown in the Fig.2. The scheme of the iUPQC is very similar to the conventional UPQC, using an association of the SAF and PAF, diverging only from the way the series and shunt filters are controlled. In the iUPQC, the SAF works as a current source, which imposes a sinusoidal input current synchronized with the grid voltage. The PAF works as a voltage source imposing sinusoidal load voltage synchronized with the grid voltage. In this way, the iUPQC control uses sinusoidal references which is derived from transfer function for both series and shunt active filters.

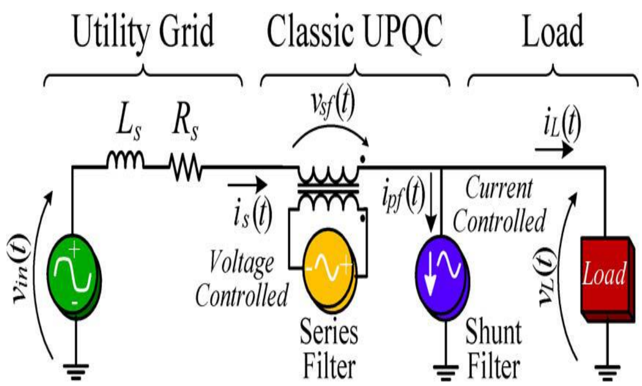

Fig. 1. Conventional UPQC.

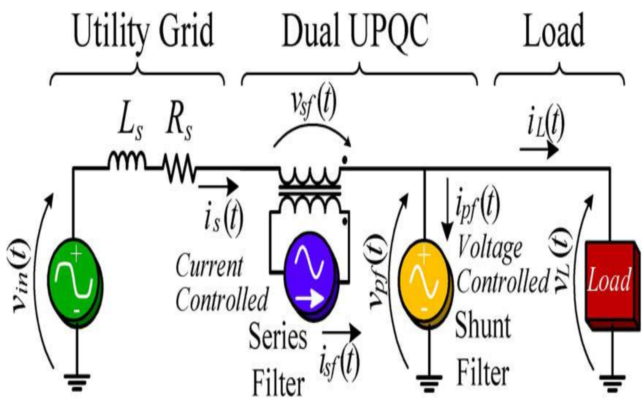

Fig. 2. Dual UPQC (iUPQC).

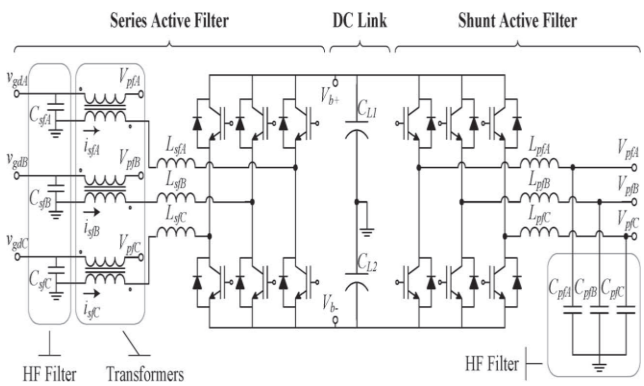

Fig. 3. Power circuit of the iUPQC.

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III. PROPOSED CONTROL SCHEME

The proposed iUPQC control structure in an ABC reference frame based control, where the SAF and PAF are controlled in an independent way, shown in Fig. 3. In the proposed control scheme, the power calculation and harmonic extraction are not needed since the harmonics, unbalances, disturbances, and displacement should be compensated. The Series Active Filter (SAF) has a current loop in order to ensure a sinusoidal grid current synchronized with the grid voltage. The PAF has a voltage loop in order to ensure a balanced regulated load voltage with low harmonic distortion.

These control loops are independent from each other since they act independently in each active filter. The dc link voltage control is made in the SAF, where the voltage loop determines the amplitude reference for the current loop, in the same mode of the power factor converter control schemes. The sinusoidal references for both SAF and PAF controls are generated by a digital signal processor, which ensure the grid voltage synchronism using a phase locked loop.

III. SAF CONTROL

The SAF control scheme consists of three identical grid current loops and two voltage loops. The current loops are responsible for tracking the reference to each grid input phase in order to control the grid current independently. One voltage loop is responsible for regulating the dc link voltage, and the other is responsible for avoiding the unbalance between the dc link capacitors shown in the Fig. 4. The total dc voltage control loop has a low-frequency response and determines the reference amplitude for the current loops. Thus, when the load increases, overcoming the input grid current, the dc link supplies momentarily the active power consumption, resulting in a decrease of its voltage. This voltage controller acts to increase the grid current reference, aiming to restore the dc link voltage. In the same way, when the load decreases, the voltage controller decreases the grid current reference to regulate the dc link voltage. Considering the three phase input current, sinusoidal and balanced, the voltage loop transfer function is obtained through the method of power balance analysis.

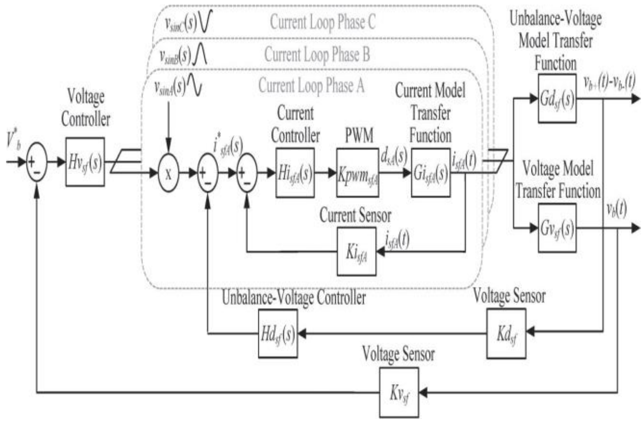

Fig 4. Control block diagram of the SAF controller.

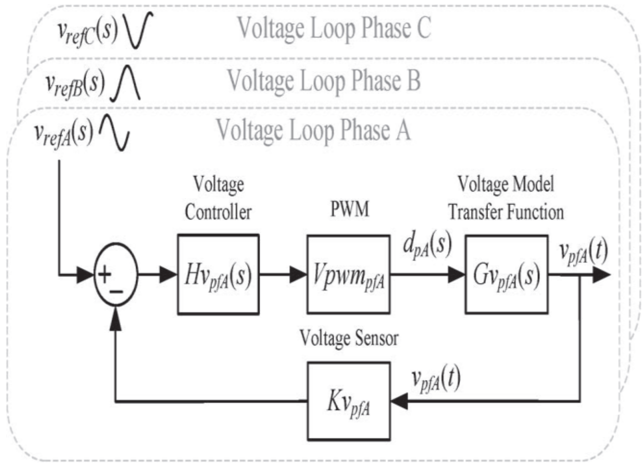

Fig.5. Control block diagram of the PAF voltage loop.

V. PAF CONTROL

The PAF control scheme is formed by three identical load voltage feedback loops, except for the 120o phase displacements from the references of each other. The voltage loops are responsible for tracking the sinusoidal voltage reference for each load output phase in order to control the load voltages independently shown in Fig. 5. The voltage loop transfer function is obtained through the analysis of the single-phase equivalent circuit shown in Fig. 5. The dynamic model is obtained through the circuit analysis using average values related to the switching period. Through small signal analysis by using Laplace transformation.

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VI SIMULATION RESULATS

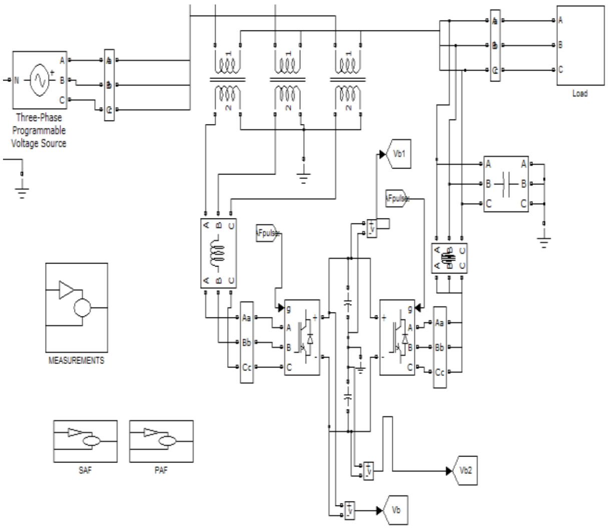

Fig.6. Mat lab Simulation Circuit

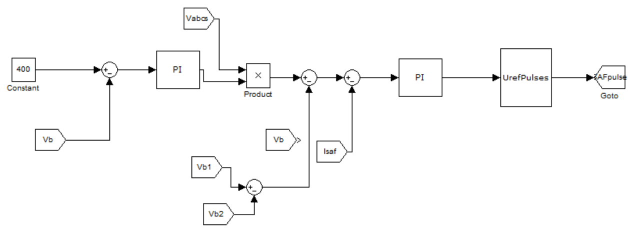

Fig.7. Mat lab SAF CONTROL

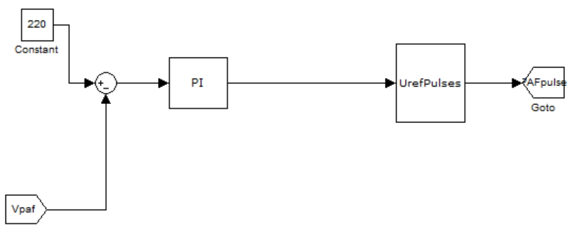

Fig.8. Mat lab PAF CONTROL

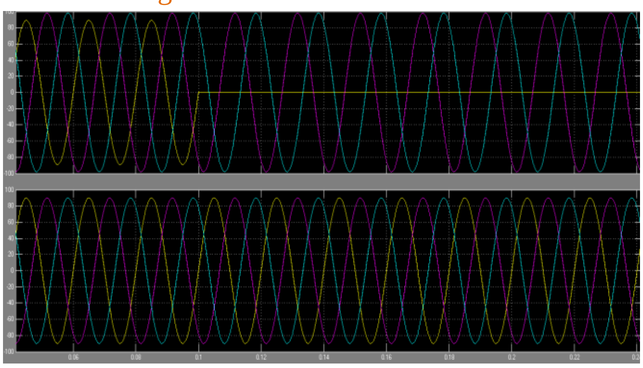

Fig..9 Source voltages and load voltages

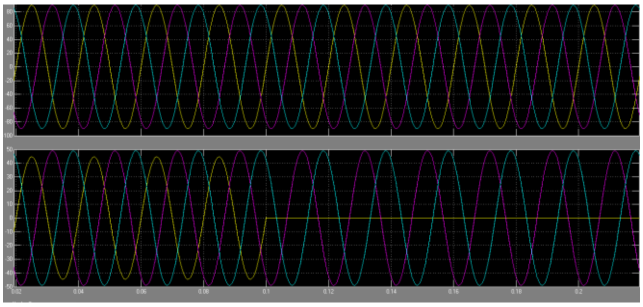

Fig.10 Load voltages (100 V/div and 10 ms/div) and sourcecurrents (5 A/div and 10 ms/div).

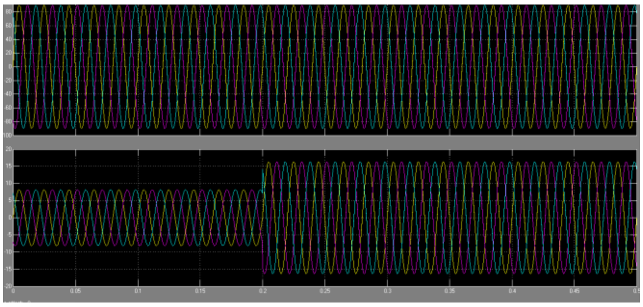

Fig 11 Load voltages (100 V/div and 5 ms/div) and load currents (5 A/div and 5 ms/div) during a load step from 50% to 100%.

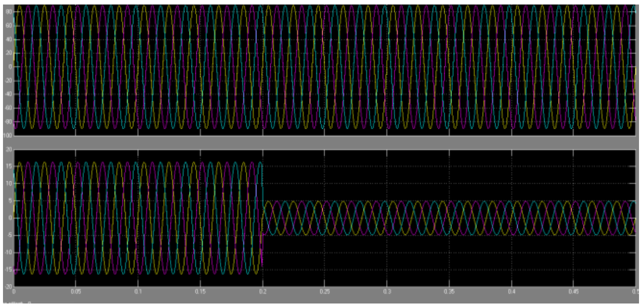

Fig 12 Load voltages (100 V/div and 5 ms/div) and load currents (5 A/div and 5 ms/div) during a load step from 100% to 50%.

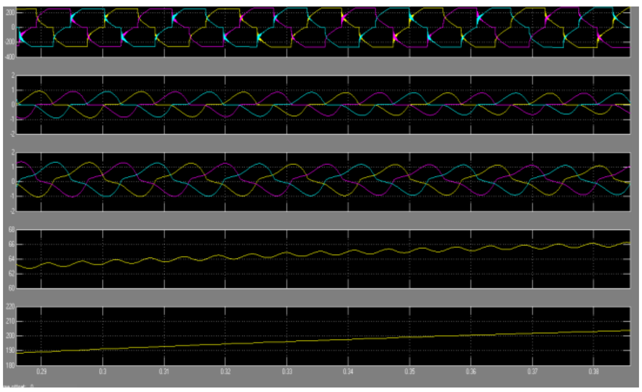

Fig 13.Vsaf,Isaf,Ipaf,Vb1,Vb2

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VII. CONCLUSION

The paper presented the control techniques design to improve the power quality by reducing the harmonic distortion. The simulation results of solar panel and three phase inverter are presented a simplified controltechnique for a dual three-phase topology of a unified powerquality conditioner (iUPQC) to be used in the utility gridconnection. The proposed control scheme is developed in ABCreference frame and allows the use of classical control theorywithout the need for coordinate transformers and digital controlimplementation. The references to both SAF and PAFs are sinusoidal,dispensing the harmonic extraction of the grid current and load voltage. . The output Voltage and output power of the PV panel are obtained. All the simulations are performed in matlab/simulink modeling and simulation platform.

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