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Single Stage Three Phase Grid Tied Pv System with Universal Filtering Capability Applied to DG Systems and AC Microgrids

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ABSTRACT

Generally, one of the custom power devices in FACTS called unified power quality conditioner, which is used to compensate the voltage and current-related Power Quality issues in the distribution systems. In this paper it proposes a 3-phase system using single stage conversion for a 4-wire, grid connected PV system. It operates with dual compensating strategy. The system uses a feed forward control loop. Apart from active power injection into the grid, the system works as a UPQC. For harmonics current reduction and reactive power compensation .so that output is harmonics free voltage. As well as variable and balance one. UPQC works as a dual compensator. In this as sinusoidal current source act by a series converter and sinusoidal voltage perform by a parallel converter. The flawless conversion can be done for different modes like interconnected and islanding modes. Moreover, solar irradiation variations give problems.

KEY WORDS: UPQC, Series Controller, Shunt Controller, Current Controller, Microgrid and Harmonics.

1. INTRODUCTION

In the advancement of power semiconductor devices, such as thyristors, Gate Turn off thyristors, Insulated Gate Bipolar Transistors and many more devices, which are used to control electric power.

In three phase systems, the power electronics devices could also cause unbalances in voltage and draw excessive neutral currents due to their disturbances. Due to because of these injected harmonics, reactive power burden, unbalance, and excessive neutral currents causes efficiency reduction and poor power factor. Therefore, improvement of power quality is one of the important issues since many loads at various distribution ends. Basically, the term Power Quality mainly deals with problems occurred in the system like improvement of voltage levels at the Point of Common Coupling (PCC) for various distribution voltage levels irrespective of voltage fluctuations, maintaining near unity power factor power drawn from the supply, blocking of voltage and current unbalance from passing upwards from various distribution levels, reduction of voltage and current harmonics in the system and suppression of excessive supply neutral current. Conventionally, passive LC filters has been used but these devices have the demerits of fixed compensation, large size, ageing and resonance. Nowadays these constraints cannot be overcome otherwise, while maintaining the required system stability, by mechanical means without lowering the useable transmission capacity. By providing added flexibility, FACTS controller can enable a line to carry power closer to its thermal rating. Mechanical switching needs to be supplemented by rapid-response power electronics [13]. The facts technology can certainly be used to overcome any to the stability limits, in which case the ultimate limits would be thermal and dielectric.

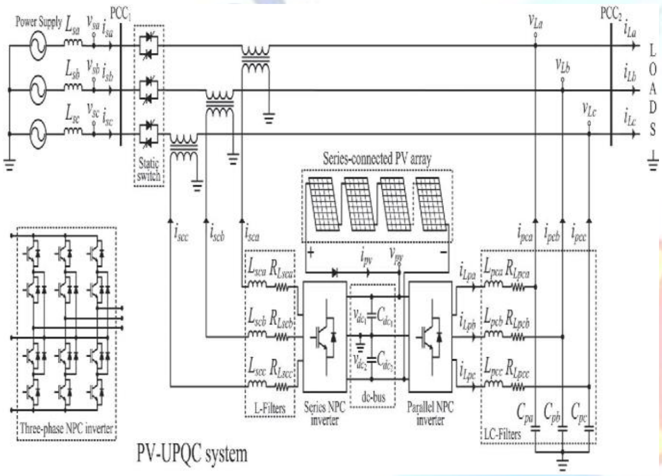

Figure 1: Complete power circuit of the PV-UPQC system connected to a conventional electrical distribution system

2. UNIFIED POWER FLOW CONTROLLER

The block diagram representation of Unified Power Quality Conditioner is shown in Figure 2. The voltage at PCC may be or may not be distorted depending on the other non-linear loads connected at PCC. This diagram has two converters such as series and shunt which are connected with the common dc link capacitor. First converter is connected shunt with the transmission line at load side commonly called as shunt APF, helps in compensating load harmonic current as well as to maintain dc link voltage at constant level. Another converter is connected in series with utility voltage by series injection transformers called as series converter and it helps in maintaining the load voltage sinusoidal.

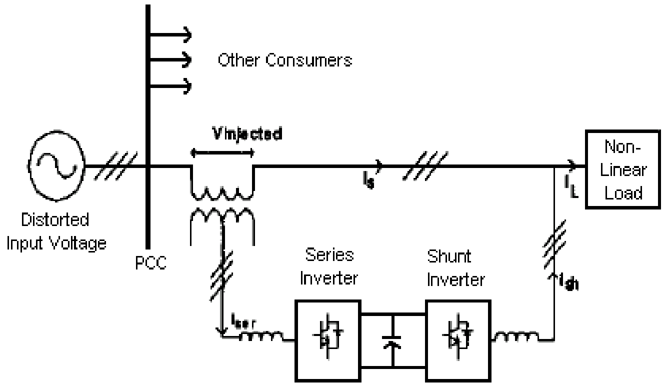

Figure 2: single line diagram of UPQC

The controlling technique for series and shunt converter of UPQC is designed based on the block diagram shown in figure 3 and 4.

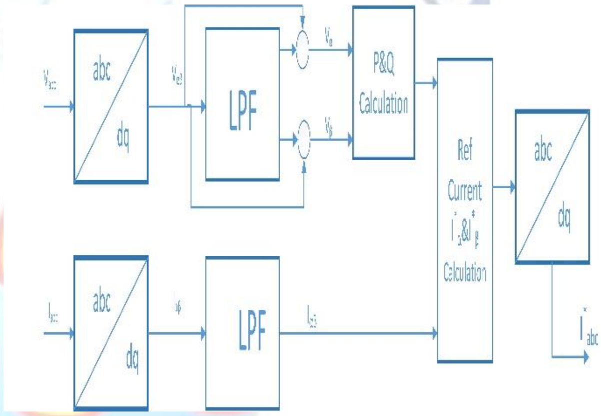

Figure 3: Block diagram of overall control structure with Series converter

The series converter, as mentioned in the previous section, is applicable for achieving multi-level control objectives. Hence, the block "function selection and combination" in Figure 3, indicates that different objectives can be integrated into the system by choosing appropriate reference signals [12] isα, isβ, isγ. Details about the unbalance correction scheme, which is used to generate current reference for negative-sequence voltage Compensation. For the power control strategy, which are used to obtain desired currents for active/reactive power transfer.

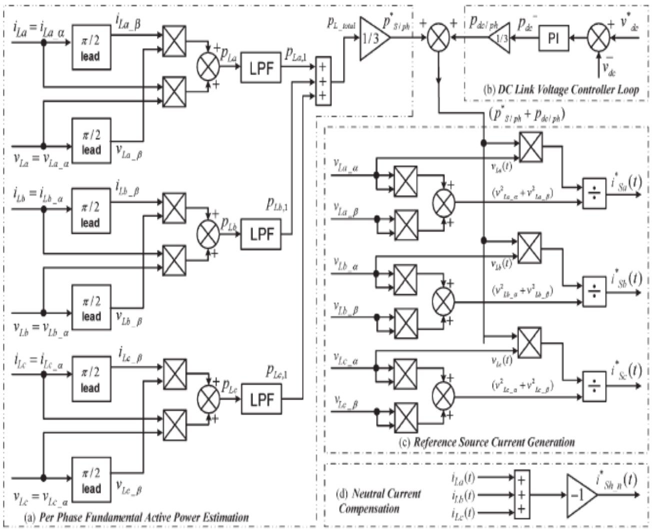

Figure 4: Control Diagram Shunt converter

Based on the load on the 3Phase system, the current drawn from the utility can be unbalanced. The current unbalance present in the load currents can be compensated by expanding the concept of single-phase p-q theory. According to this theory, a signal-phase system can be represented in α-β- coordinates, and thus, the p-q theory applied for balanced three-phase system can also be used for each phase of unbalanced system independently.

The actual load voltages and load currents are considered as α-axis quantities, whereas the π/2 lead load or π/2 lag voltages and π /2 lead or π/2 lag load currents are considered as β-axis quantities. In this paper, π/2 lead is considered to achieve a two-phase system for each phase.

For phase a, the load voltage and current in α-β coordinates can be represented by π/2 lead as

$$\begin{bmatrix} v_{La\_\alpha} \\ v_{Lb\_\beta} \end{bmatrix} = \begin{bmatrix} v^*_{La}(\omega t) \\ v^*_{La}(\omega t + {}^{\pi}/_{2}) \end{bmatrix} = \begin{bmatrix} V_{Lm}sin(\omega t) \\ V_{Lm}cos(\omega t) \end{bmatrix}$$

$$\begin{bmatrix} i_{La\_\alpha} \\ i_{La\_\beta} \end{bmatrix} = \begin{bmatrix} i_{La}(\omega t + \varphi_L) \\ i_{La}[(\omega t + \varphi_L) + {}^{\pi}/_{2}] \end{bmatrix}$$

Considering phase *a*, the phase-*a* instantaneous load active and instantaneous load reactive powers can be represented by

$$\begin{bmatrix} p_{La} \\ q_{La} \end{bmatrix} = \begin{bmatrix} v_{La\_\alpha} & v_{La\_\beta} \\ -v_{La\_\beta} & v_{La\_\alpha} \end{bmatrix} \cdot \begin{bmatrix} i_{La\_\alpha} \\ i_{La\_\beta} \end{bmatrix}$$

Where $p_{La} = \bar{p}_{La} + \tilde{p}_{La}$, $q_{La} = \bar{q}_{La} + \tilde{q}_{La}$

PV Solar System:

Solar PV system play a key role in distribution energy systems in present scenario as its flexibility and reliable nature. The PV system converters sun irradiance to electrical energy by photon effect. In PV system the solar cells are arranged in series and parallel combination to meet the load requirement such as voltage and current. The main components in solar system is, PV panel which converters sun photon light to electrical current further it converted to dc voltage with the help of electrical equivalent circuit. To reach, the maximum power from the solar system an MPPT based DC-DC converter is implemented.

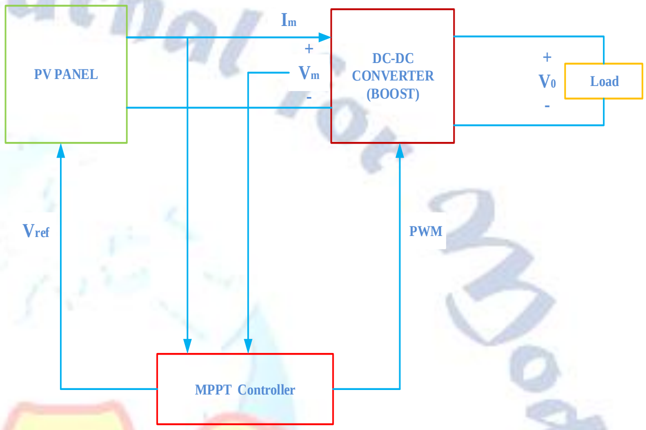

Figure 5: PV System with Power Converter

The purpose of MPPT technique is to track the power from the solar system. A maximum power point tracker is a basic DC to DC converter that synchronize between the PV system and PCC point. The purpose of this converter is to control the solar voltage and track the maximum power from the panels. The mathematical analysis and modelling of PV system is expressed in the following equation. The electrical equivalent circuit diagram for PV panel with single diode is shown in figure 6.

$$I = I_{ph1} - I_{D1} - I_{sh1}$$

$$I = I_{ph} - I_o[e^{(\frac{qV_D}{nKT})}] - (\frac{V_D}{R_s})$$

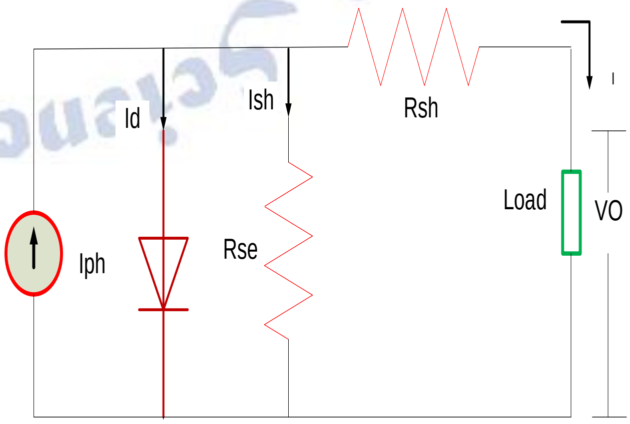

Figure 6: PV Electrical Equivalent circuit

3. SIMULATION RESULTS:

The experimental setup is done in MATLAB/SIMULINK as per the circuit shown in figure 1.

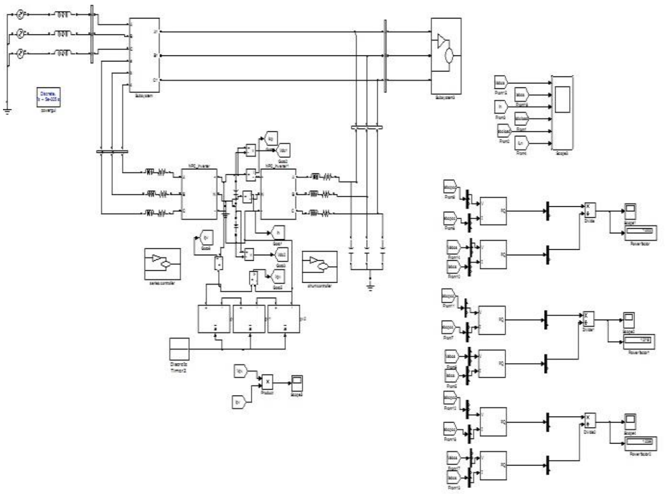

Figure 7: Simulation Diagram of 3P4W UPQC system

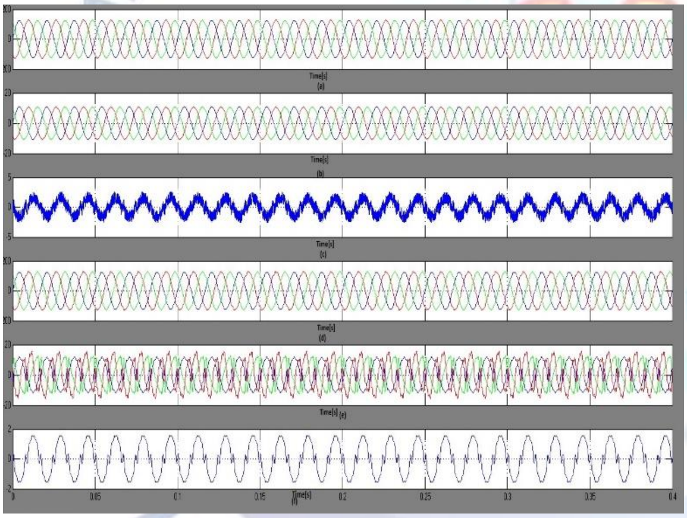

Figure 8: Matlab/Simulink source and load voltages

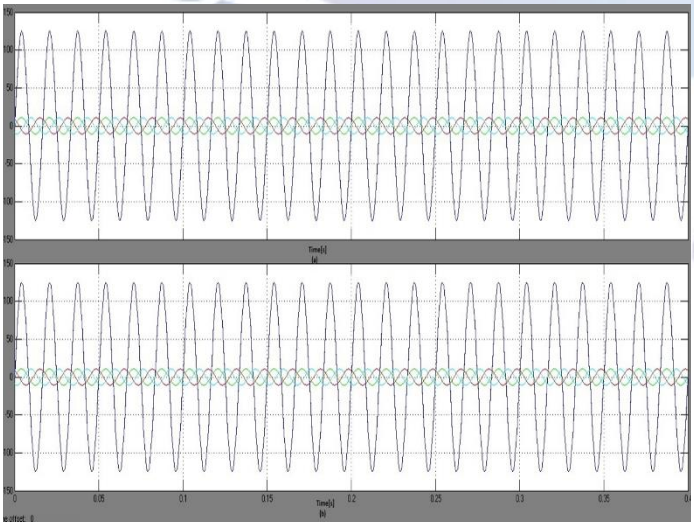

Figure 9: Matlab/Simulink (a)grid voltage (Vsa) and grid currents (Isa, Isb, Isc) (b)load voltage (Vla) and parallel NPC inverter currents (Ipca, Ipcb, Ipcc)

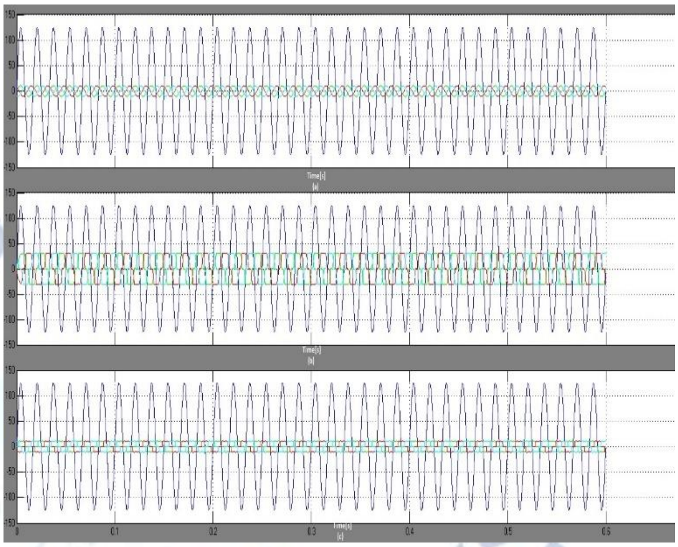

Figure 10: Matlab/Simulink a) Grid voltage (Vsa) and grid currents (Isa, Isb, Isc) b) Load voltage (Vla) and parallel NPC inverter currents (Ipca, Ipcb, Ipcc) c) Load voltage (Vla) and load currents (Ila, Ilb, Ilc)

4. CONCLUSION

This project has proposed a Single stage 3phase 4wire grid tied PV system performing the tasks of a UPQC operating with a dual compensating strategy and also as FFCL. The system PV-UPQC was built with the help of two back-to-back connected three level NPC inverters. Along with providing active power from the PV arrangement the PV-UPQC system was able to perform series-parallel power line conditioning. The effectiveness of the FFCL acting on the series converter current references was properly evaluated under sudden solar irradiation changes. The proposed PV-UPQC system hence represents a promising solution to be applied to DG systems, as well as AC micro grids.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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