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A Review on Design and Performance Analysis of 3 Phase Solar Integrated PV-UPQC

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ABSTRACT: Today it is very important to provide clean, reliable and continue power to the consumer from supply authority. Due to the increasing customers and use of modern power electronic devices, there is number of disturbances in quality of power such as voltage sag, swell, harmonics. Hence , In order to maintain quality of power, different power electronic devices have been used. In this project, we used unified power quality conditioner with solar PV array to maintain good power quality. UPQC is the combination of series and shunt compensator which performs multi task to improve the quality of power. The proposed system combines both the benefits of distributed generation and active power filtering. The shunt compensator of the PV-UPQC compensates for the load current harmonics and reactive power. It takes power from PV array. The series compensator compensates for the grid side power quality problems such as grid voltage sags/swells by injecting appropriate voltage in phase with the grid voltage. Reference signal is generated by using synchronous reference frame control based on moving average filter.

KEYWORDS: Power Quality, shunt compensator, series compensator, UPQC, Solar PV.

I.INTRODUCTION

There is an increased integration of renewable energy systems such as solar and wind energy into modern distribution systems because it is environmental friendly. These sources of energy are intermittent in nature. The loads present in modern distribution system are mainly power electronics based loads which are highly non-linear. The increased installation of renewable energy sources and non-linear loads result in several power quality problems both at load and grid side [1]. These power electronic loads though energy efficient, inject harmonic currents into grid which cause distortion at point of common coupling (PCC) particularly in weak grid systems. Furthermore, these power electronic loads are sensitive to disturbances in voltages. In weak distribution systems, due to the intermittent nature of the clean energy sources such as wind and solar energy, their increased penetration leads to PCC voltage fluctuations depending upon power generation and demand.

These voltage fluctuations can affect sensitive power electronic loads such as adjustable speed drives, lighting systems etc which can lead to frequent tripping, malfunction and thus leading to increased maintenance costs. Renewable energy integration with power quality enhancing systems such as dynamic voltage restorer (DVR), unified power quality conditioner (UPQC) and distribution static compensator (DSTATCOM) provides an ideal solution by combining benefits of clean energy with power quality enhancement [2]. Efforts are being made by many researchers for the effective improvement of power quality. UPQC is considered as the most powerful solution to the problems arising due to power quality. It is adequate enough to take care of supply voltage disturbances like voltage sag/swells, voltage flickers, load reactive power as well as voltage and current harmonics. The UPQC can also be named as the universal active power line conditioner, universal power quality

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conditioning system and also universal active filter. It is a cascade connection of series and shunt active power filter (APF) connected through a common DC link capacitor [3].

II. SYSTEM CONFIGURATION AND DESIGN

Basic Structure of UPQC: UPQC is the combination of series and shunt converter. Basic structure of UPQC is as shown in fig. 1. The role of series inverter inject compensated voltage in series with the load voltage when source voltage become unbalanced and non sinusoidal. Series compensator injects or absorb voltage at the required magnitude and phase angle which can solve the problem of voltage sag, swell . Series inverter absorbs / inject real power in addition to reactive power. The shunt converter has the ability to regulate the dc link voltage and compensate the current related PQ issues [5]-[6].

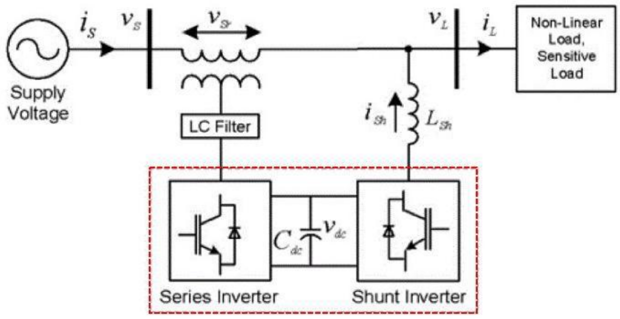

Fig. 1. Basic structure of UPQC

System Configuration

UPQC is used to eliminate distortions of voltage and is used for reactive power compensation. In UPQC series compensator is used as voltage source inverter to compensate for voltage distortions and make voltage at load side completely balanced and sinusoidal. It injects a voltage which is difference of source voltage and perfectly balanced load voltage. Shunt compensator is used for compensation of reactive power. It is also used to maintain value of DC link capacitor constant[6]. The structure of the PV-UPQC is shown in Fig. 2.The PV-UPQC is designed for a three-phase system.

The PV-UPQC consists of shunt and series compensator connected with a common DC-bus. At load side, shunt compensator is connected. The solar PV array is directly integrated to the DC-link of UPQC through a reverse blocking diode. The series compensator used to compensate the voltage which can reduce the voltage sag and swell. The shunt and series compensators are connected to the grid through interfacing inductors. A series compensator injects the voltage into the grid by using series injection transformer. Harmonics are generated by converters are eliminated by using filters[8].

The magnitude of DC link voltage Vdc depends on the depth of modulation used and per-phase voltage of the system. The DC-link voltage magnitude should more than double the peak of per-phase voltage of the three phase system. The load used is a nonlinear load consisting of a bridge rectifier with a voltage-fed load. The DC-link capacitor is sized based upon power requirement as well as DC-bus voltage level. The interfacing inductor rating of the shunt compensator depends upon the ripple current, the switching frequency and DC-link voltage.

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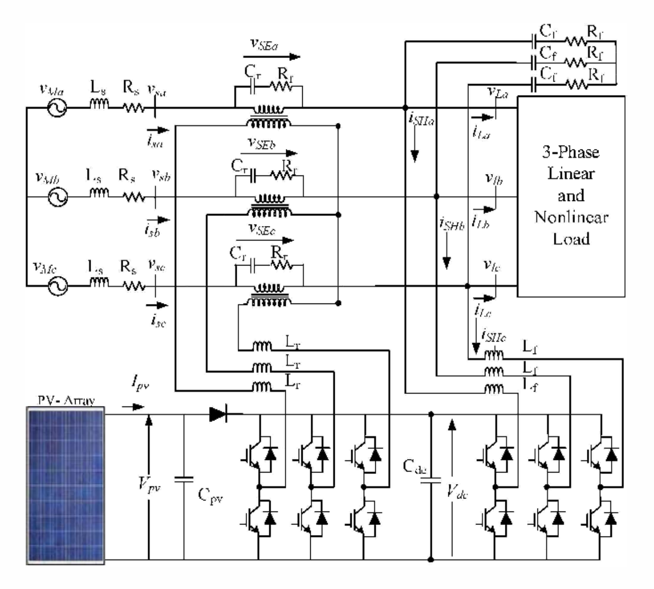

Fig. 2. System configuration of UPQC

Comparison of various Custom Power Devices:

S. No	Factors	DSTATCOM	DVR	UPQC
1	Rating	low rating	high rating	higher ratings are available
2	Speed of operation	Less than DVR	Fast	Faster
3	Compensation Method	Shunt Compensation	Series Compensation	Both series & shunt
4	Active /reactive Power	Reactive	Active/ Reactive	Both
5	Harmonics	Less	Very less	Lesser
6	Problems addressed	Sag/ Swell	Sag/ Swell/ Harmonics	Sag/ Swell/ Harmonics/ Flicker/ Transients/ unbalance in 3 phase system
7	Cost	Nominal	High	Higher

III. CONTROL STRATEGY

Control Strategy for shunt compensator: The measured load current is transformed into the synchronous d-q-o reference frame. By this transform, the fundamental positive- sequence component, which is transformed into dc quantities in the *d* and *q* axes, can be easily extracted by low-pass filters (LPFs). Also, all harmonic components are transformed into ac quantities with a fundamental frequency shift. The shunt compensator extracts the maximum power from the solar PV array by operating at its maximum power point .The maximum power point tracking(MPPT) algorithm generates the reference voltage for the DC link of UPQC. Current from dc link is converted to the reference grid currents. The reference grid currents are compared with the sensed grid currents is given to hysteresis controller. Hysteresis controller generate the gating pulses for shunt converter. To extract

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DC component without deteriorating the dynamic performance, a moving average filter (MAF) is used to extract the DC component.

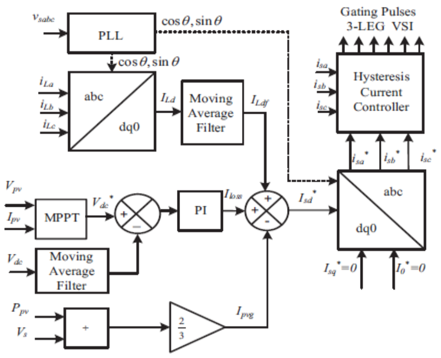

Fig. 3 .Control Structure of Shunt Compensator

Control of Series Compensator: The bus voltage is detected and then transformed into the synchronous dq0 reference frame. The control strategy for the series compensator are pre-sag compensation, in phase compensation and energy optimal compensation. In this work, the series compensator injects voltage in same phase as that of grid voltage, which results in minimum injection voltage by the series compensator. The control structure of the series compensator is shown in Fig.4 The fundamental component of PCC voltage is extracted using a PLL which is used for generating the reference axis in dq-0 domain. The reference load voltage is generated using the phase and frequency information of PCC voltage obtained using PLL.

The PCC voltages and load voltages are converted into d-q-0 domain[7]. As the reference load voltage is to be in phase with the PCC voltage, the peak load reference voltage is the d-axis component value of load reference voltage. The q-axis component is kept at zero. The difference between the load reference voltage and PCC voltage gives the reference voltage for the series compensator. The difference between load voltage and PCC voltage gives the actual series compensator voltages. The difference between reference and actual series compensator voltages is passed to PI controllers to generate appropriate reference signals. These signals are converted to a-b-c domain and passed through pulse width modulation (PWM) voltage controller to generate appropriate gating signals for the series compensator.

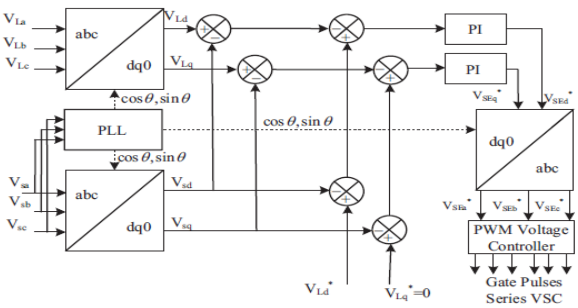

Fig.4 .Control Structure of Series Compensator

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IV. ADVANTAGES

- Integration of clean energy generation and power quality improvement.
- Simultaneous voltage and current quality improvement.
- Improved load current compensation due to use of MAF in d-q control of PV-UPQC.
- Stable under various dynamic conditions of voltage sags/swells, load unbalance and irradiation variation.

V. APPLICATIONS

- Power system based applications
- Utility grid interactive applications

VI. CONCLUSION

Degradation of power quality due to increased penetration of distributed energy resources and power electronic devices concern to improving the power quality. UPQC is a type of advance hybrid filter which reduces voltage related problems like voltage sag/swell, fluctuation, etc . It can be seen that PV-UPQC is a good solution for modern distribution system by integrating distributed generation with power quality improvement. This paper presents review on UPQC to mitigate PQ issues. Available systems are compared with UPQC and its control strategies are presented.

VII. ACKNOWLEDGMENT

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