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DESIGN AND PERFORMANCE ANALYSIS OF 3PHASE SOLAR PV INTEGRATED UPQC

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***ABSTRACT*- Today power system demand is increasing. In recent year's power degraded at distribution side and Power loss is increasing at consumer side due to more uses of non-linear load. Power Quality issues created by sensitive load. In this paper MAF based UPQC device used to reduce voltage and current distortions. In this paper we use UPQC which consists of a series compensator and a shunt compensator and the PV cell is connected in between shunt and series connected voltage compensators. The compensator in series to a source is used to mitigate the voltage harmonics between the sources and loads. Whereas the shunt active filter is connected in parallel with the load is used to reduce and the harmonic currents produced by the load, reduce the total harmonic distortion (THD), extracting power from PV circuit, and increase the power factor of the system. The Synchronous reference frame based control is used in shunt and series compensators in UPQC. In this paper the power Quality can be improved by reduction of distortions leads to increase in efficiency of power system. The performance of MAF based UPQC is demonstrated by simulating the developed system design in MATLAB/Simulink under a Non-linear load.**

Index Terms—Power Quality, shunt compensator, series compensator, UPQC, Solar PV,MPPT.

I.INTRODUCTION

With the advancement in semiconductor technology, there is an increased penetration of power electronic loads. These loads such as computer power supplies, adjustable speed drives, swtiched mode power supplies etc. have very good efficiency, however, they draw nonlinear currents. These nonlinear currents cause voltage distortion at point of common coupling particularly in distribution systems. There is also increasing emphasis on clean energy generation through installation of rooftop PV systems in small apartments as well as in commercial buildings [1], [2]. However, due to the intermittent nature of the PV energy sources, an increased penetration of such systems, particularly in weak distribution systems leads to voltage quality problems like voltage sags and swells, which eventually instability in the grid [3]–[7].

These voltage quality problems also lead to frequent false tripping of power electronic systems, malfunctioning and false triggering of electronic systems and increased heating of capacitor banks etc [8]–[10]. Power quality issues at both load side and grid side are major problems faced by modern distribution systems. Due to the demand for clean energy as well as stringent power quality requirement of sophisticated electronic loads, there is need for multifunctional systems which can integrate clean energy generation along with power quality improvement. A three phase multi-functional solar energy conversion system, which compensates for load side power quality issues has been proposed in [11], [12]. A single phase solar pv inverter along with active power filtering capability has been proposed in [13], [14]. Major research work has been done in integrating clean energy generation along with shunt active filtering. Though shunt active filtering has capability for both load voltage regulation, it comes at the cause of injecting reactive power. Thus shunt active filtering cannot regulate PCC voltage as well as maintain grid current unity power factor at same time. Recently, due to the stringent voltage quality requirements for sophisticated electronics loads, the use of series active filters has been proposed for use in small apartments and commercial buildings [15], [16]. A solar photovoltaic system integrated along with dynamic voltage restorer has been proposed in [17]. Compared to shunt and series active power filters, a unified power quality conditioner (UPQC), which has both series and shunt compensators can perform both load voltage regulation and maintain grid current sinusoidal at unity power factor at same time. Integrating PV array along with UPQC, gives the dual benefits of clean energy generation along with universal active. The integration of PV array with UPQC has been reported in [18]–[20]. Compared to conventional grid connected inverters, the solar PV integrated UPQC has numerous benefits such as improving power quality of the grid, protecting critical loads from grid side disturbances apart from increasing the fault ride through capability of converter during transients. With the increased emphasis on distributed generation and micro grids, there is a renewed interest in UPQC systems [21], [22]. Reference signal generation is a major task in control of PV-UPQC. Reference signal generation techniques can be broadly divided into time-domain and frequency domain techniques [8]. Time domain techniques are commonly used because of lower computational requirements in real-time implementation. The commonly used techniques include instantaneous reactive power theory (p-q theory), synchronous reference frame theory (d-q theory) and instantaneous symmetrical component theory [23]. The main issue in use of synchronous reference frame theory based method is that during load unbalanced condition, double harmonic component is present in the d-axis current. Due to this, low pass filters with very low cut off frequency is used to filter out double harmonic component. This results in poor dynamic performance [24]. In this work, a moving average filter (MAF) is used to filter the d-axis current to obtain fundamental load active current. This gives optimal attenuation and without reducing the bandwidth of the controller [25]. Recently, MAF has been applied in improving performance of DC-link controllers as well as for grid synchronization using phase locked loop (PLL).

In this paper, the operation of UPQC is observed in detail. A boost DC-DC converter is employed to interface solar oriented PV cluster with DC connection of UPQC. The dynamic power from the solar based PV display is infused into the lattice by means of the shunt converter. The Voltage and Current Harmonics are compensated by series and shunt compensators respectively using SRF controller. The Objective of this paper, is to design a MAF based UPQC and to increase the Quality of the power.

II. SYSTEM CONFIGURATION AND DESIGN

Fig1 Unified Power Quality Conditioner (UPQC) is capable of performing more than one function i.e. it is a multi function power conditioner. UPQC can be employed to avoid harmonic load current from entering the power system, to rectify voltage fluctuation and to indemnify various voltage disturbances of the ability provide. It is a custom power device proposed to alleviate the conflicts that influence the performance of sensitive and/or essential loads. UPQC has series and shunt compensation ability for (voltage and current) harmonics, voltage disturbances (including flicker, sag, swell etc.), reactive power, and power-flow control. Usually, a UPQC composed of two voltage-source inverters (VSI’s) with a standard dc link intended in single phase, three-phase three-wire, or three-part four-wire patterns. One electrical converter is regulated as a changeable voltage supply within the series compensator (APF or DVR)

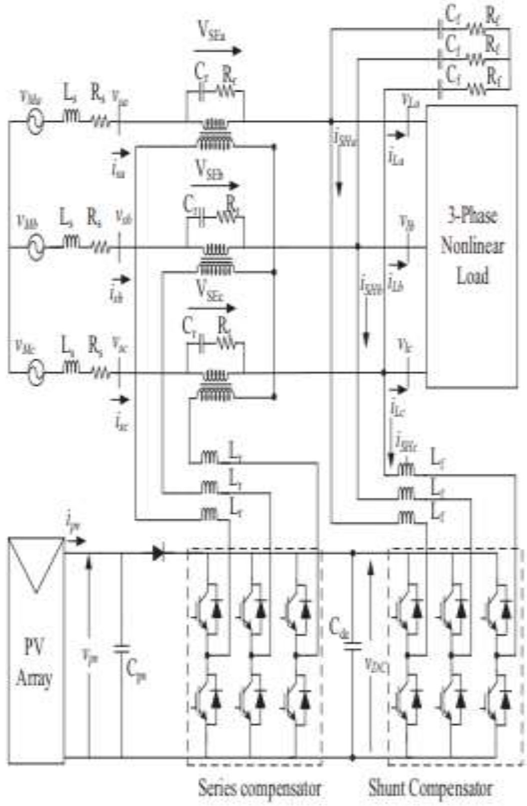

Fig.1. System Configuration PV-UPQC

The additional inverter is regulated as a changeable current source in the shunt active power filter (APF). The series inverter balances for voltage supply distortions (e.g. including harmonic disparities, negative and zero sequence elements, sag, swell, and flickers).The shunt APF converter reimburses for load current disturbances (e.g. caused by harmonics, disparities), execute the dc link voltage regulation and reimburses the reactive power.

III. CONTROL DESIGN:

a)Series electrical converter: It's a voltage-source inverter linked in series with AC line through a series transformer and operates as a voltage supply to mitigate voltage disturbances. It eradicates supply voltage flicker and imbalances from the load terminal voltage. Management of the series electrical converter output is performed by victimization pulse width modulation (PWM).Among the assorted PWM technique, the hysteresis band PWM is usually used because of its easy implementation. Also, besides quick response, the tactic doesn't want any data of system parameters. During this work hysteresis band PWM is employed for the management of inverters.

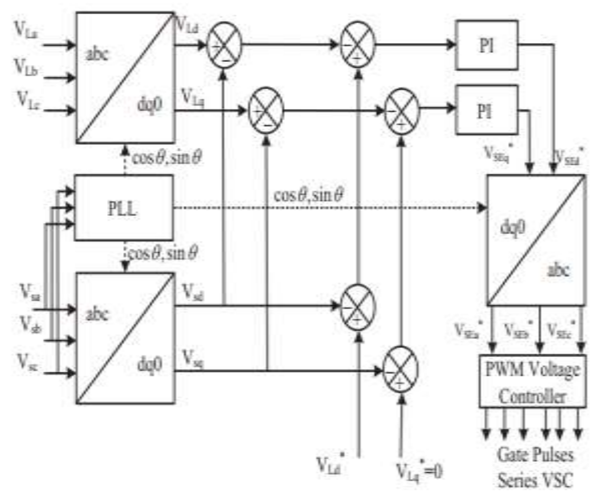

Fig3.1:Control Structure of Series Compensator

b) Shunt inverter:

It's a voltage-source inverter connected in shunt with an analogous AC line that acts to cancel current distortions, compensate reactive current of the load and improve the power factor of the system. It together performs the DC-link voltage regulation, leading to a big reduction of the DC capacitor rating. The output current of shunt device is adjusted by using a dynamic hysteresis band by dominant the standing of the semiconductor switches like output current follows the reference signal and remains in a much planned hysteresis band.

c) DC link capacitor:

The 2 VSI's are connected back to back with one another through this capacitor. The voltage across this electrical condenser provides the independent DC voltage for correct operation of each inverter. With correct management, the DC link voltage acts as a supply of active as well as reactive power and so eliminates the necessity of external DC supply like battery.

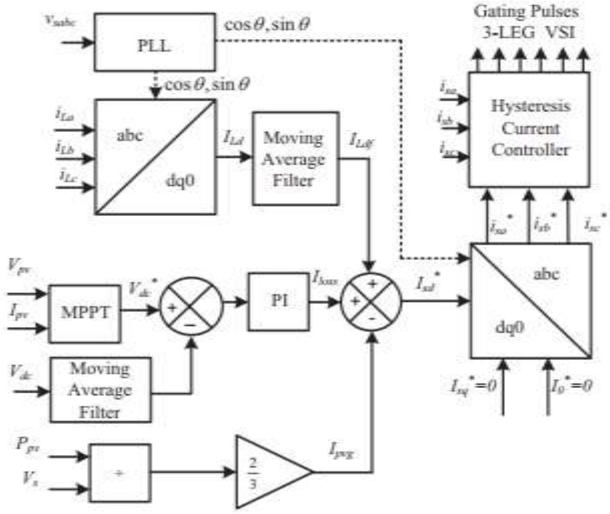

Fig3.2: Control Structure of Shunt Compensator

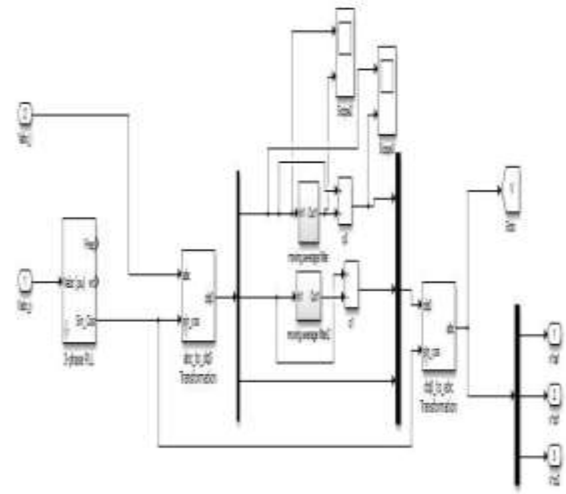

Fig 4.2 SRF Control for Series Converter

d)Low pass filter:

It is used to attenuate high-frequency components of the voltages at the output of the series converter that are generated by high frequency switching of VSI.

e) High pass filter:

It is installed at the output of shunt converter to absorb ripples produced due to current switching.

f) Series transformer:

The necessary voltage generated by the series inverter to retain a pure sinusoidal load voltage and at the preferred value is injected into the line through these series transformers. An appropriate turn's ratio is frequently considered to diminish the current flowing through the series inverter.

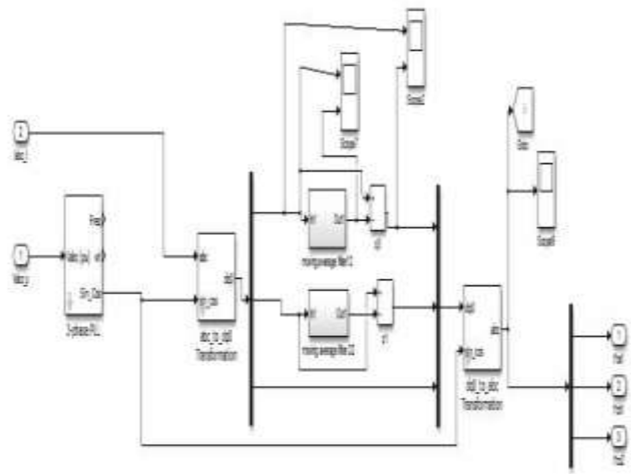

Fig 4.3 SRF Control for Shunt Converter

1V.SIMULATION DIAGRAMS

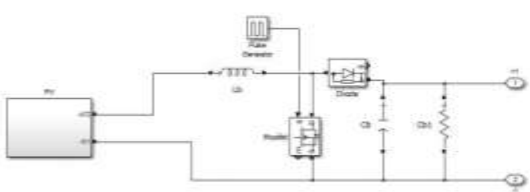

Fig 4.1 PV Module with Boost Converter

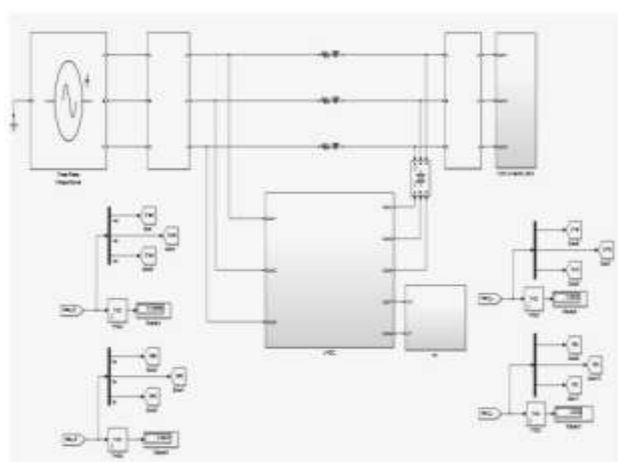

Fig 4.4 Simulink model for MAF based UPQC

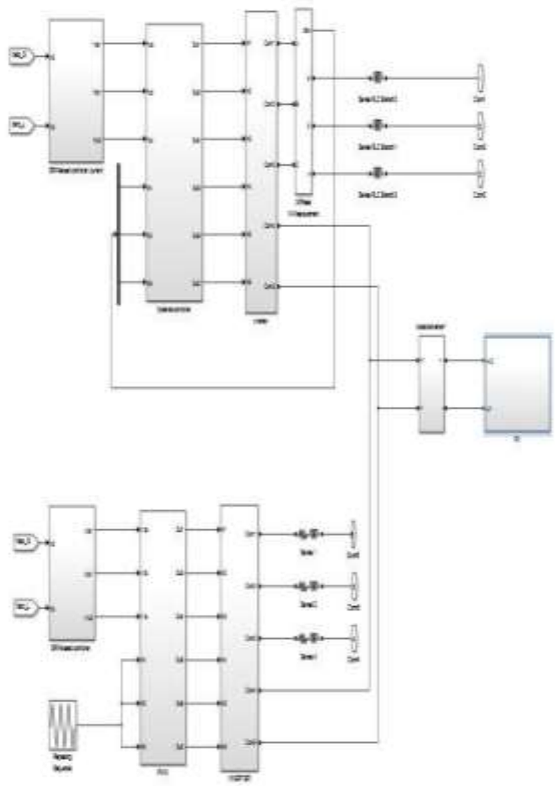

Fig 4.5 Unified Power Quality Conditioner

V.SIMULATION RESULTS

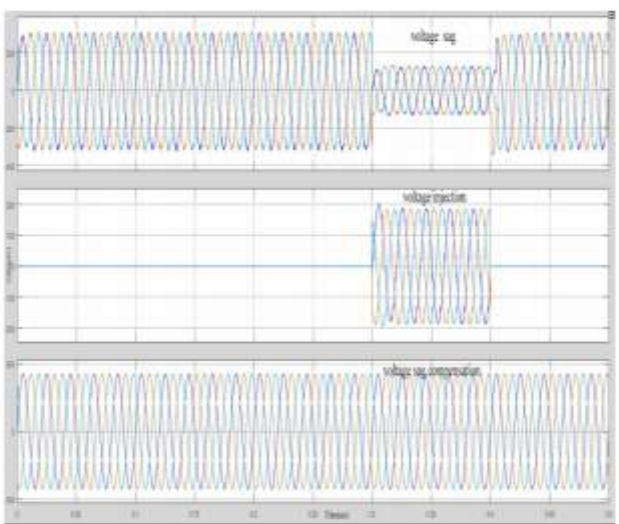

Fig: 5.1 Voltage Sag Compensation Waveforms in PV – UPQC

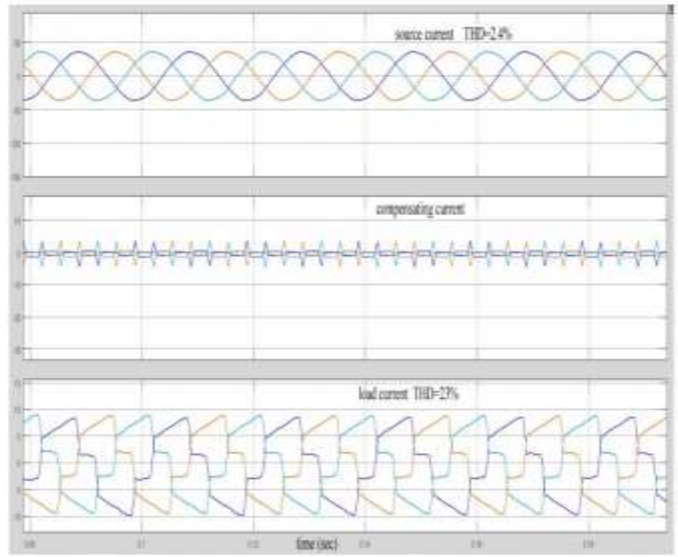

Fig: 5.2 Mitigation of Current Harmonics waveforms in PV - UPQC

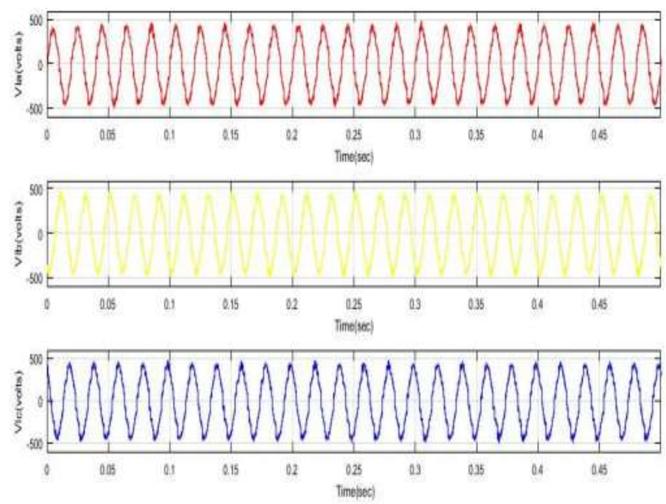

Fig 5.3: Load voltage waveforms

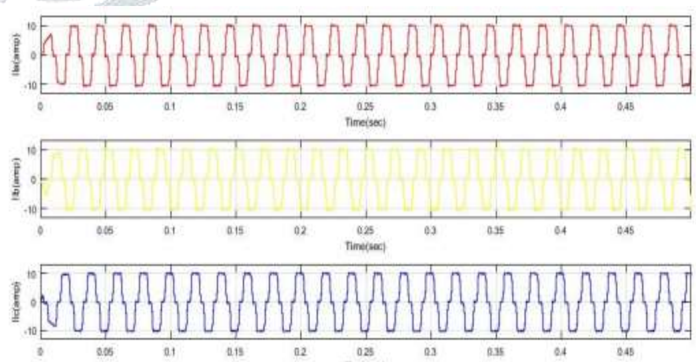

Fig 5.4: Load current waveforms

CONCLUSION

In this paper, mitigation of current and voltage harmonics using MAF based UPQC has been presented and tested under a non-linear load. Introduction of PV system in UPQC at DC link fed the supply voltage to link capacitors as well as fed power to the loads. The performance of SRF based controller particularly in non-linear load condition has been improved through the use of MAF. Introduction of SRF based controlling for MAF based UPQC reduces the harmonics, increases the power factor of the system and also maintains the percentage of THD under the limits of IEEE-519 standards.

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