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A New Sapf Control Power Quality Improvement In Pv Source Integrated Micro Grid Applications For Hormonic Rejection

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ABSTRACT--*In recent times the power generated by PV source is growing at a fasterrate andaffect the electric power generation market in the way of power prices. But it is very challenging to integrate with distribution system because it directly affects the power quality in a distribution system. This paper proposes a new strategy for power quality (PQ) improvement in a Micro-grid connected PV system is proposed in this paper.This paper present an active power component theory based shunt active power filter (SAPF) to integrate the PV source at Micro-Grid distribution level with the significant reduction of the harmonic. The control strategy mainly consists of the Calculate reference current template,Regulate the DC voltage across PV source and Generation of firing pulses. Overall a high accuracy in source current is achieved by a current control loop, which influences the performance of APF-PV system with fast dynamic response. The fuzzy controller used to compensate DC voltage by voltage control loop. It is also important to note that APC offers a smaller total harmonic distortion of the source current with integrated PV. The steady state and dynamic performance of proposed scheme has been tested by simulation under a diode bridge rectifier load RL in balance & unbalance condition.*

Index Terms*— Active Power Component (APC), Shunt Active Power Filter (APF), Point of Common Coupling (PCC), Renewable Energy Source (RES).*

I. INTRODUCTION

Centralized power generation systems are facing the twin constraints of shortage of fossil fuel and need to reduce the emissions. Long distance transmission line are one of the main causes for electrical power losses. So, emphasis has increased on distributed generation (DG) networks with integration of renewable energy systems into the national grid, which lead to efficiency and reduction in emissions. With the rise of the renewable energy penetration into the grid, power quality of low voltage power transmission system is becoming a major area of interest. Most of available integration of renewable energy systems to the grid takes place with the aid of power electronics converters. The primary use of the power electronic converters is to integrate the DG to the grid in compliance with power quality standards. But, high frequency switching of inverters can inject more harmonics to the systems, creating major PQ problems if it is not implemented properly. The widespread utilization of nonlinear loads is prevalent in distribution systems because the utilizer required the compact and low energy consumable contrivances. Generally those contrivances are predicated on power electronics and microelectronics. These two technologies are considerably amended the quality of modern life. But, at the time of the nonlinearity and unbalance condition, same sensitive technologies are conflicting with each other and engender a challenge to maintain quality of accommodation in form of poor power factor, incremented heating losses, transient and steady state perturbance nearby PCC [1]. Ultimately end users suffer from poor power quality quandaries and pay adscititious electricity penalty and in an industry it may be loose customer productivity. Conventionally, passive LC filters have been used to solve this type of quandary [1]. However, there are lot of inhibitions like as fine-tuned emolument, sizably voluminous size, tuning quandary, exile resonance conditions and inability to compensate transmuting harmonic current content [1-4]. Active power filters are now visually perceived as a viable alternative solution over the classical passive filters, to compensate harmonics and reactive power requisite of the non-linear loads, because of its excellent performance characteristics and simplicity in implementation, both in single and three phase system [1]. Sundry control strategies of SAPF have been published from past long years [5-7], but PV source integration with 3P4W grid is popular to compensate the harmonic as well as to transfer the potency [8]. From the kinds of literature [1-8], generally control strategy mainly consists of the Calculate reference current template, Regulate the DC voltage across the capacitor andProduction of firing pulses.

Reference current template generations conventionally involve sundry techniques, but in this paper APC method has been used due to expeditious dynamic replication and less intricacy. Overall a high precision in source current is achieved by a current control loop, which mainly influences the performance of APF system with expeditious dynamic replication. The fuzzy controller is utilized to compensate DC voltage. The wide literature has been published in reference [8,9]. The solar power generations are utilized for ameliorating the load demand power with power quality amelioration at the PCC. Firstly the domestic load is supplied by solar power with battery bank, when power demand or load varies; the system is automatically connected through grid and supply/consumes the balance puissance. At a time of load variation, harmonics are engendered in the system. The mundane DC link voltage of VSC is regulated utilizing a fuzzy logic controller. The grid interfaced RES has been developed in [11,12]. This control technique is comparatively more reliable. The resoluteness isThe maximum allowable voltage drop at PCC.The characteristics of the expected voltage and current harmonics to be compensated.Interconnection of solar energy to micro- grid.The simulation and analysis study given in this paper and it fixates on study state and dynamic state comportment of the system as well as harmonic emolument in the system.

II. DESIGN OF SAPF SYSTEM

Most of the active power filter topologies use voltage source converters, which are a voltage source at the dc bus, usually a capacitor, as an energy storage device. This topology, shown in Figure 1, converts a dc voltage into an AC voltage by appropriately gating the power semiconductor switches. Although a single pulse for each half cycle can be applied to synthesize an AC voltage, for most applications requiring dynamic performance, pulse width modulation is the most commonly used today.

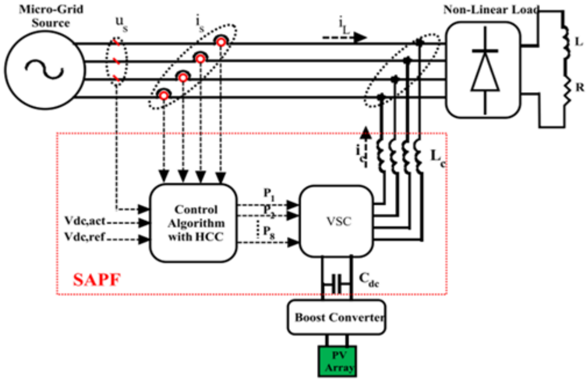

Figure 1. Configuration of Shunt Active Filter and PV Source with Micro-Grid System.

PWM techniques applied to a voltage source inverter consist of chopping the dc bus voltage to produce an AC voltage of an arbitrary waveform. With PWM techniques, the AC output of the filter can be controlled as a current or voltage source device. Voltage source converters are preferred over current source converter because it is higher in efficiency and lower initial cost than the current source converters [13]. They can be readily expanded in parallel to increase their combined rating and their switching rate can be increased if they are carefully controlled so that their individual switching times do not coincide.

Therefore, higher-order harmonics can be eliminated by using converters without increasing individual converter switching rates. The Instantaneous current & load can be written as

$$\left.\begin{array}{c} i_s = \sum_{n=1}^{\infty} I_n \sin(n\omega t + \varphi_n) \\ or \\ i_s = I_1 \sin(\omega t + \varphi_1) + \sum_{n=2}^{\infty} I_n \sin(n\omega t + \varphi_n) \\ or \\ i_s = I_{Af} + I_{Rf} + I_{Hf} \end{array}\right\} \qquad (1)$$

Where $,_{Rf}$, $I_{Hf}$is active, reactive and harmonic load current respectively.

$$\left.\begin{array}{c} P_s = V_s \times I_s \\ or \\ P_s = P_A + P_R + P_H \end{array}\right\} \qquad (2)$$

Here PA is active fundamental power. Only active fundamental components can responsible for delivering load power. The PR & PH is reactive and Harmonic power flow in the system due to unbalance & nonlinearity characteristic of a load. So active or real power drawn by the load from the source is

$$\left.\begin{array}{c} P_A = V_m I_1 sin^2 \omega t \times cos\varphi_1 \\ or \\ P_A = V_s(t) \times sin\omega t . I_1 cos\varphi_1 \\ or \\ I_1 cos\varphi_1 = \frac{P_A}{P_s(t) . sin\omega t} = I_p \end{array}\right\} \qquad (3)$$

Therefore, source current after compensation will be given by equation (3)

$$I_1 cos\varphi_1 = I_p$$

In a practical converter, there are switching, conducting and capacitor leakage losses. So that losses must be supplied by the Micro-Grid itself. Hence, total peak current supplied by Micro-Grid will be given as

$$I_{SP} = I_p + I_{sLoss} \qquad (4)$$

WhereI_{SP}= Total peak current supplied by Micro-Grid.
WhereI_{sLoss} = loss current of converter supplied by the source.

If total harmonic and reactive power of the load is supplied, by the Active Power Filter then there will not be any harmonic in source current and source current will be in phase with the source voltage. Therefore, the total source current including losses will be given as

$$i_s^* = I_{SP} sin\omega t \qquad (5)$$

So compensating current will be given as

$$i_c(t) = i_s - i_s^* \qquad (6)$$

It is obvious from above discussion that for instantaneous compensation of reactive power, in addition, harmonic power, Micro-Grid should be able to supply current i_s*. Therefore, it is necessary to find i_s* which is known as the reference current.

The several different techniques are available for generation of the reference current. These reference currents should be in phase with the supply line voltages for synchronization of SAPF output with the grid. The peak value of these currents should be as explained in equation 4. Therefore, three-phase reference current will be given as

$$\left.\begin{array}{l} i_{sa}^* = I_{SP} sin\theta \\ i_{sb}^* = I_{SP} \sin(\theta - 120^0\,) \\ i_{sc}^* = I_{SP} \sin(\theta + 120^0\,) \end{array}\right\} \qquad (7)$$

III. CONTROL STRATEGIES

The fuzzy logic controllers try to regulate/maintain the capacitor voltage at given reference value. This variation of DC capacitor voltage will govern the real power exchange between PV and grid. So this output of voltage regulator produces an Active currentIp . Now this Active current component Ip is multiplied by unity vector templates (Ua ,Ub and Uc) and generates the reference grid current. For a balanced system, the neutral current should be zero. The grid-synchronizing angle obtained from phase locked loop (PLL) is used to generate unity vector template.

$$\left.\begin{array}{l} U_a = \mathrm{Sin}\theta \\ U_b = \mathrm{Sin}\left(\theta - \frac{2\pi}{3}\right) \\ U_c = \mathrm{Sin}\left(\theta + \frac{2\pi}{3}\right) \end{array}\right\} \qquad (8)$$

As shown in the Fig.1, that capacitor voltage first passes through the low pass filter, which eliminates the high-frequency ripple from the voltage. The reference value is required to compensate capacitor voltage. This reference value decides the power exchange between PV and Point of Common Coupling (PCC). The filtered DC voltage is subtracted from the reference value and the error signal is fed to fuzzy controller. The aim of fuzzy controller is to maintain constant DC voltage under varying load conditions. The fuzzy logic controller works as a voltage regulator and generates V_{dc}, error.

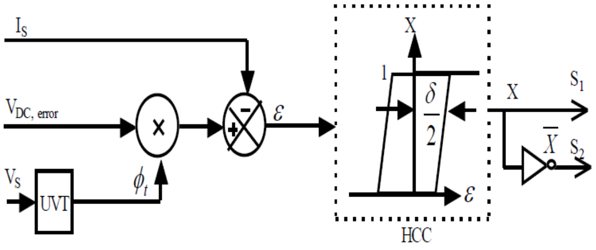

Figure 2. UVT based control Algorithm with HCC.

Now this V_{dc}, error is multiplied with UVT output and then subtracted from an actual current. After subtraction, the error is given to hysteresis controller as shown in Fig.2. Hysteresis controller is generating switching signal for four legs IGBTs (P1 to P8.). Now these gate pulses are driven the IGBTs. The requirement of a neutral load current is compensated through the fourth leg of voltage source converter.

IV.SIMULATION RESULTS

Fuzzy logic based SAPF with PV model is simulated in MATLAB. The complete SAPF system is composed mainly of three-phase four wire source with a nonlinear load as a voltage source PWM converter. A diode rectifier with R-L load is taken as non-linear load and use as balanced as well as unbalanced condition. The parameters selected for simulation studies are given in appendix ”A”.A highly nonlinear characteristics based load is considered for performance study. The THD in the load current is 30

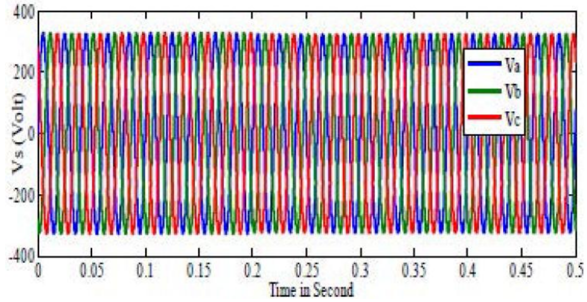

Figure 3.Micro-grid Voltage.

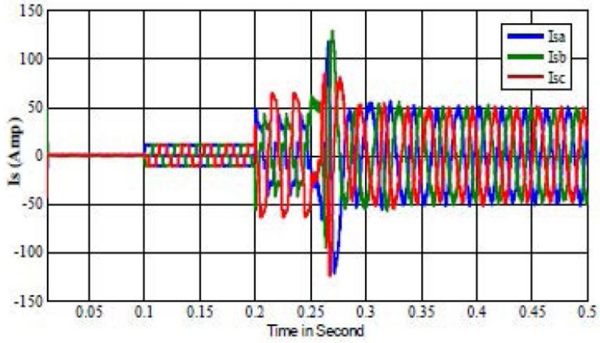

Figure 4.After compensation Micro-grid system Current Waveform.

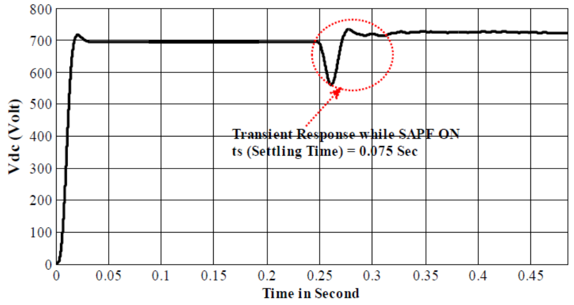

Figure 5.DC Voltage Response across the Capacitor.

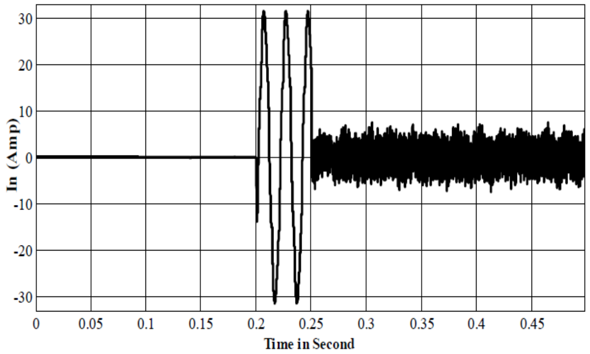

Figure 6.Neutral Current Compensation in System.

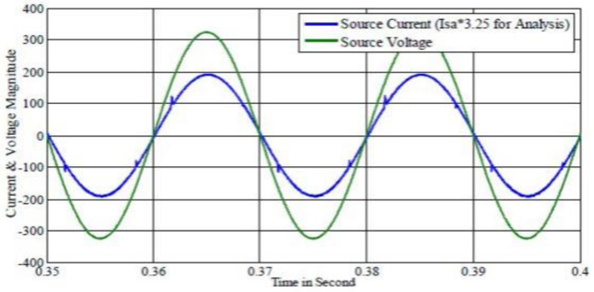

Figure 7.Power Factor with Compensator (phase "a").

TABLE:1

THD ANALYSIS

Currents	Total RMS before Compensation	Total RMS after Compensation	THD%
Phase a	62.52	50.92	1.16
Phase b	39.70	49.84	0.88
Phase b	40.38	48.74	1.00

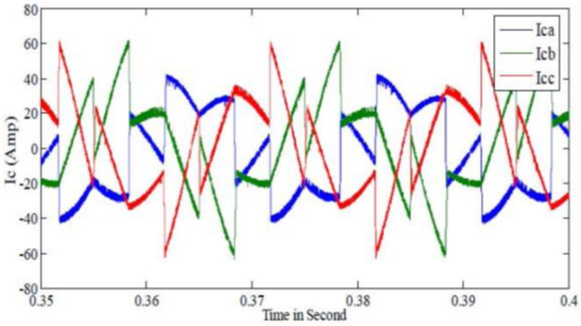

Figure 8. Compensating Current Generated by SAPF

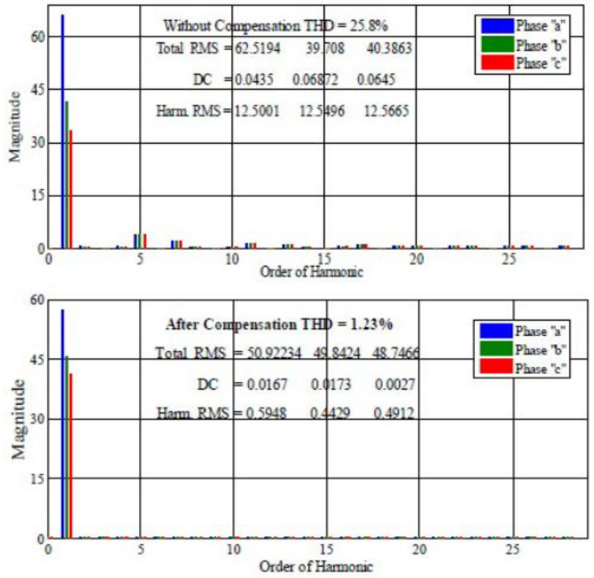

Figure 9.FFT Analysis of Source Current before and After Compensation.

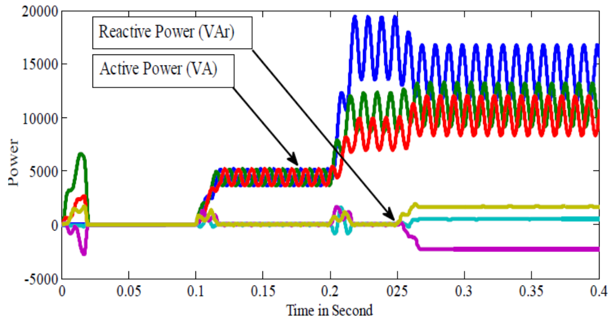

Figure 10.Representation of Power Consumption by Load.

The compensator is switched ON at t=0.25sec. The source currents before and after compensation are shown in Fig. 4. However, some transients are produced during synchronizing at PCC. From the Fig.5, the DC voltage responses across a capacitor are depicted switching of SAPF, hence, here the settling time required is 0.075 sec. Also, the neutral current compensation gives better performance with fuzzy controller shown Fig.6. Fig.7 shoes the improvement of power factor. Fig.8 represents the compensation current. The reduction of harmonic distortion with compensator is shown in Fig. 9. The source current THD is reduced near to 1.23% in overall current with PV. Fig.10 represents the active & reactive power consumption of load.

V.CONCLUSION

PV based SAPF simulated in MATLAB is implemented for harmonic and reactive power compensation of the non-linear load at PCC purpose. The simulation results show the improvement in power quality of the Micro-Grid distribution system by eliminating harmonics and reactive power compensation of non-linear load, which makes the load current sinusoidal and in phase with the source voltage.

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