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Utility Current Compensation by PV-Active Power Filter

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Abstract - *As we know demand is increasing towards renewable energy like wind, solar, etc. It gives us pollution free energy. So, the photovoltaic (PV) generation is increasingly popular nowadays because of its reliable performance and its ability to generate clean energy resources., while typical loads require more high-power quality basically, one PV generator supply to nonlinear hundreds is desired to be integrated with a operate as a full of life active power filter (APF). during this paper, a three-phase three-wire system, together with a close PV generator, dc/dc boost device to extract most radiation power mistreatment most wall plug trailing, associate degreed dc/ac voltage supply device to act as an APF, is given. The instantaneous power theory is applied to style the PV-APF controller that shows reliable, performances. The MATLAB/Sim power Systems tool has proven that the combined system will at the same time inject most power from a PV unit and compensate the harmonic current drawn by nonlinear hundreds.*

***Key Words*: Active power filter (APF), Instantaneous power theory, photovoltaic (PV), power quality, renewable energy**

1. INTRODUCTION

The environmental issues become a worldwide issue. Whereas the energy demand is considerably increasing against the decreasing reserves of fossil and fissile resources, the electrical phenomenon (PV) energy as an in exhaustible and clean supply will reply thereto demand. Joined of distributed sources, the PV power is more and more connected to the grid, either in large scale and small-scale plants. Thus, the PV supply should give the most of its output power, and a most outlet chase (MPPT) technique is employed. MPPT formula allows extracting the most of power regardless of the operative environmental condition, star irradiance (g) and PV cell temperature. Power provides and power quality is vital problems in power grid recently. The grid-connected electrical phenomenon (PV) generator has today become a lot of widespread as a result of its reliable performance and its ability to get power from clean energy resources. The dc output voltage of PV arrays is connected to a dc/dc boost convertor employing a most outlet chase (MPPT) controller to maximize their made energy. Then, that converter is linked to a dc/ac voltage source converter (VSC) to let the PV system push electric power to the ac utility. The local load of the PV system can specially is a non- linear load, such as computers, compact capability, which makes currents injected/absorbed fluorescent lamps, and many other home appliances, that requires distorted currents. Development of a means to compensate the distribution system harmonics is equally urgent. In this case photovoltaic generators should provide the utility with distorted compensation by the utility to be sinusoidal. Therefore, the harmonic compensation function can be realized through flexible control of dc/ac voltage converter source.

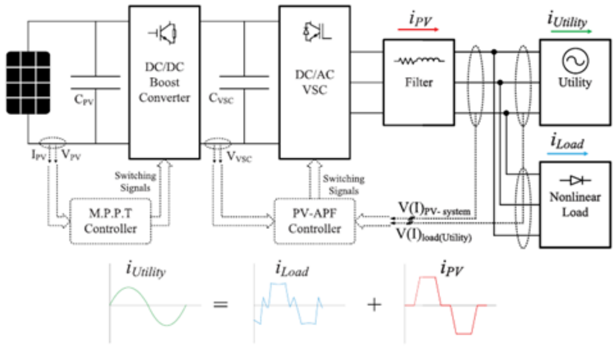


Fig-1: Block diagram of system

2. LITERATURE REVIEW

The combined operation of the active power filter with the photovoltaic generation system is expressed [1]. The proposed system consists of a PV power plant, a DC–DC boost converter, and an active power filter [2]. A novel control strategy for the DC– DC converter has been developed in order to extract the maximum amount of power from PV arrays [6]. Also, a novel the overall efficiency of photovoltaic systems connected to the grid depends on the efficiency of direct current (DC) of the solar modules to alternate current (AC) inverter conversion [4]. The requirements for inverter connection include: maximum power point, high efficiency, control power injected into the grid, high power factor and low total harmonic distortion of the currents injected into the grid [7]. An approach to power factor control and reactive power regulation for PV systems connected to the grid using field programmable gate array (FPGA) is proposed. According to the grid demands; both the injected active and reactive powers are controlled [9].A new digital control strategy for a single-phase inverter is carried out. This control strategy is based on the phase shift between the inverter output voltage and the grid in order to control the power factor for a wide range of the inverter output current and consequently the control and the regulation of the reactive power will be achieved. The advantage of the proposed control strategy is its implementation around simple digital circuits [10]. The various compensation strategies for shunt active power filter using a generalized theory of instantaneous reactive power. A general instantaneous vector expression for filter current in terms of active and reactive powers has been derived.

The general time domain algorithm for filter reference currents in terms of source powers has been given. It is shown that the algorithm works under balanced and unbalanced source voltages while producing a set of balanced three-phase source currents at a desired power factor [8]. Power electronics-based zonal direct current (dc) power distribution systems are being considered for sea and undersea vehicles. The stability of the dc power electronics-based power distribution systems is a significant design consideration because of the potential for negative-impedance-induced instabilities. In this paper, the dynamic properties and control of a buck converter feeding a downstream dc–dc converter are studied. The controller in this system combines an instantaneous current feedback loop using hysteresis with a proportional–integral (PI) algorithm to regulate the output voltage of the converter. Based on a large-signal-averaged model of the converter, the stability-in-large around the operation point is presented. The complete analysis is carried out considering a buck dc–dc converter operating with a constant power load (CPL). Simulations and experimental results are provided to verify the analysis.

3. PHOTOVOLTAIC ARRAY

Grid-connected Photovoltaic systems have increased dramatically in the last few years due to the increased global interest in renewable energy sources and the growth in energy demand. Consequently, new and modern control strategies should be applied to improve the efficiency, reliability, and stability of grid-connected PV systems. Joined of distributed sources, the PV power is more and more connected to the grid, either in large-scale and small-scale plants. Thus, the PV supply should give the most of its output power, and a most outlet chase technique is employed. Maximum power point tracking formula allows extracting the most of power regardless of the operative environmental condition, star irradiance and photovoltaic cell temperature. Powers provide and power qualities are vital problems in power grid recently. The grid-connected electrical phenomenon photovoltaic generator has today become a lot of widespread as a result of its reliable performance and its ability to get power from clean energy resources. The dc output voltage of PV arrays is connected to a dc/dc boost convertor employing a most outlet chase controller to maximize their made energy. Then, that converter is linked to a dc/ac voltage source converter to let the PV system push electric power to the ac utility. The local load of the PV system can specially is a non- linear load, such as computers, compact fluorescent lamps, and many other home appliances, that requires distorted currents. Development of a means to compensate the distribution system harmonics is equally urgent. In this case PV generators should provide the utility with distorted compensation capability, which makes currents injected/absorbed by the utility to be sinusoidal. Therefore, the harmonic compensation function can be realized through flexible control of dc/ac voltage converter source.

3.1 Proposed design of PV-AP combination

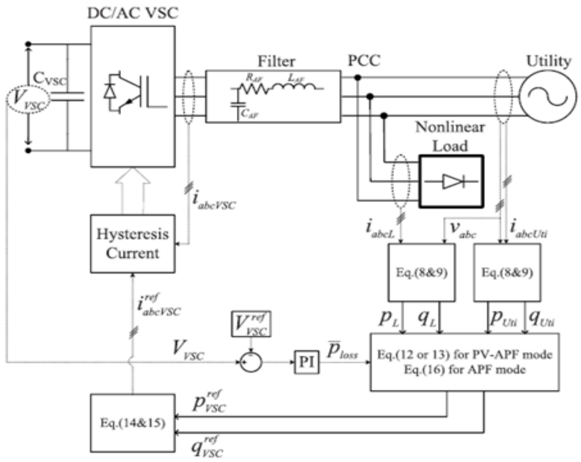


Fig-2: Controller topology of dc/ac VSC in the PV-APF combination

The detailed PV-APF configuration is shown in Figure which consists of the following.

1) The PV 5series-66parallel array, which is Sun Power SPR- 305-type, delivers a maximum of 100-[kW] power at 1000- W/m2 solar irradiance, assuming that there is no battery storage system connected to the dc bus.

2) A 5-kHz boost dc/dc converter implements MPPT by an incremental conductance integral regulator technique, which automatically varies the duty cycle in order to generate the required voltage to extract maximum power.

3) The dc bus is connected to a two-level three-phase dc/ac VSC with a C VSC capacitor. The dc/ac VSC converts the dc to ac supplying to Local nonlinear loads and connects to a stiff utility. The pq- current and PV-APF and APF controllers are applied for this dc/ac VSC subsequently.

4) A 10-kVAr capacitor bank filters out switching harmonics produced by the dc/ac VSC.

5) The loads include a three-phase diode rectifier supplying a current of 450 or 50 [A] at dc side and one-phase diode rectifier with 50-[A] dc current connecting between phase A and phase B to make an overall unbalanced load.

6) This PV-APF combination system is connected directly to the utility for shunt active filter implementation.

4. FUZZY LOGIC CONTROLLER FOR MPPT

The proposed fuzzy-based MPPT block diagram is shown in Figure 3. Figure 4 presents the structure of the fuzzy controller that has two inputs and one output. The fuzzy membership function has been designed by trapezoidal method for both input and output membership values. The defuzzification of proposed fuzzy controller has been used for center of gravity.

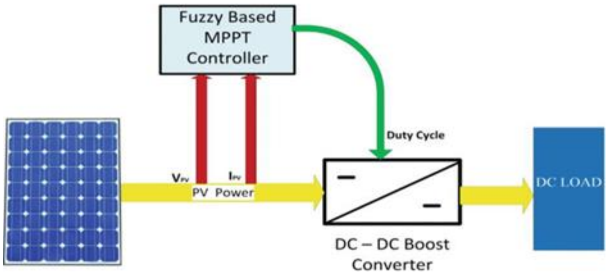


Fig-3: A fuzzy-based MPPT block diagram

The MPPT fuzzy controller has two inputs such as PV voltage and PV current. The MPPT fuzzy controller generates a duty cycle based on input of fuzzy controller and is fed into boost converter. Finally, the fuzzy interference rules are designed based on changes in PV voltage and current under various weather conditions and then the surface view of fuzzy rules is presented. The above designed fuzzy controller has been implemented in MATLAB simulation of PV system and its boost converter.

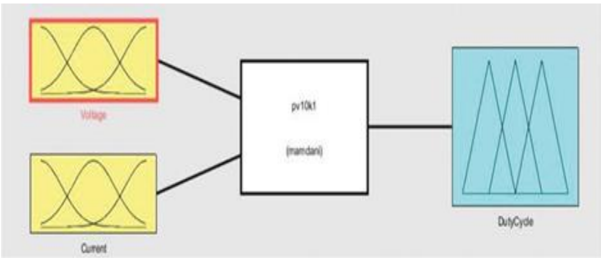
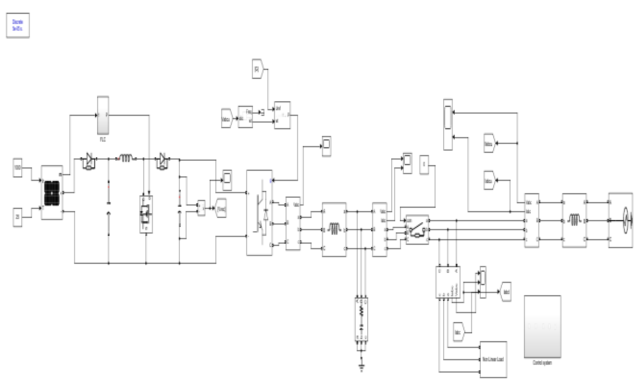


Fig-4: Fuzzy controller structure for MPPT of PV system

5. SIMULATION MODEL



6. RESULTS

The simulation result for PV-APF system is shown in Figure. It shows simulation result for grid current, load current and APF injected currents. From this figure, we conclude that the harmonics generated by non-linear load is going to compensate with APF converter and non-harmonic current is shown in grid current. The proposed system is tested and verified by using Matlab/Simulink shown in waveforms.

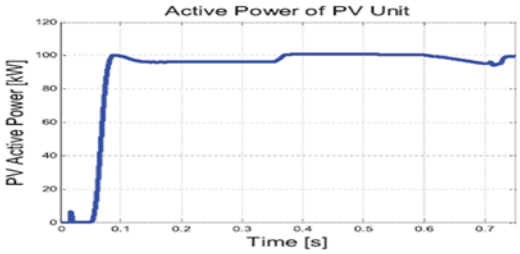


Fig-5: Output power of PV during running time

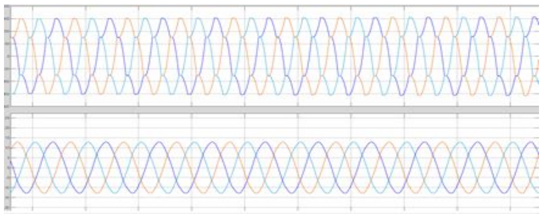


Fig-6: Utility supplied current and voltage waveform with filter

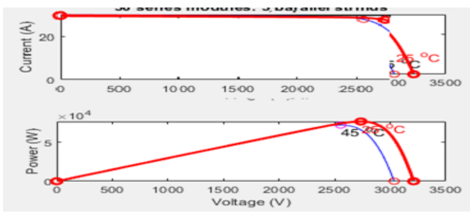


Fig-7: PV supplied voltage and current waveform

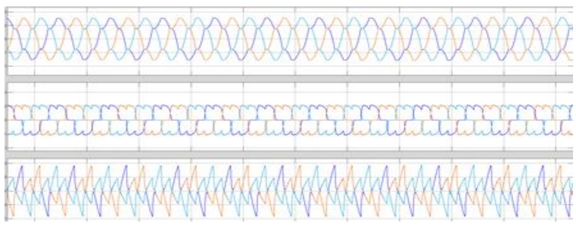


Fig-8: Load side current, voltage and inverter waveform

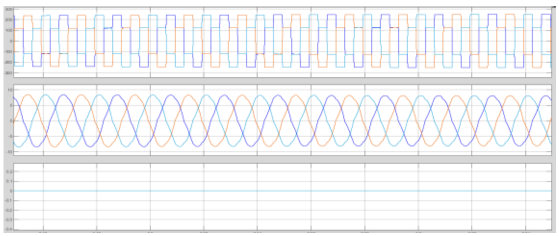


Fig-9: Load side current and voltage waveform without filter

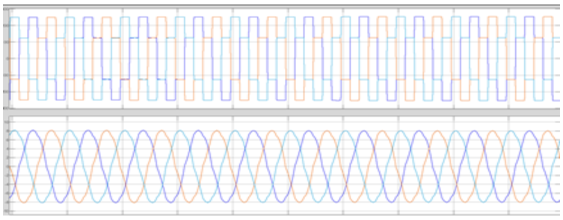


Fig-10: Utility side current and voltage waveform Without filter

7. CONCLUSION

In this paper, a dynamic grid-connected PV unit is built and the PV-APF combination system with a local controller is proposed. The controller implements two purposes, which are supplying power from the PV unit and filtering the harmonics of the local nonlinear load. The new controller based on instantaneous power balance has been explained accordingly. The MATLAB/Sim power Systems simulation shows good performances of this controller. The positive influence of MPPT on maximizing PV power output is also validated. The switching among three controllers to dc/ac VSC brings different current waveforms. As a result, the conventional pq-current controller should not be applied when PV is connected to a local nonlinear load regarding power-quality viewpoint. The PV-APF controller compensates the utility currents successfully. While a PV unit is deactivated, the APF function can still operates. A fuzzy based PV-APF controller for grid system is pro-posed in this paper for mitigating load current harmonics. The controller required in this paper is stimulated for two purposes i.e. a) acting as VSC converter between grids to PV system and b) acing as harmonic compensation current between PV systems to Non-linear load. In this paper the simulation results are compared between PI & Fuzzy controllers. The execution of this system can be tried and confirmed in Matlab/Simulink.

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