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Research paper

A Fuzzy based PV-APF Controller for Mitigation of Current Harmonics

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Abstract

This paper proposes a concept of Fuzzy based Active Power Filter for mitigating current harmonics in interconnected PV-Grid system. The PV array is connected to the utility grid by using a boost converter and a voltage source converter. For this, a three phase three wire system operated by non-linear load is considered. The increased harmonic content leads to increase in losses, decrease in power factor and many adverse effects. A Fuzzy based instantaneous PQ theory control technique is proposed in this paper for better harmonic compensation. This proposed system is tested and verified using Matlab/Simulink. The results obtained in both PI and fuzzy based APF systems are compared in the aspects of THD and active power.

Keywords: *Current Harmonics; THD; Solar System; Power Quality and MPPT*

1. Introduction

This Increased demand of sustainable power source into power grid brought forth a few difficulties those are knowledgeable about coordinating such sources among themselves and in addition with the grid. In spite of the fact that the vitality got from such sources is condition agreeable, the power and voltage acquired from such sources shifts haphazardly with the variety of climate. Besides, non-direct power converters, utilized for molding the yields from such sources, contorts the waveform and henceforth debases the nature of dispatched power subsequently influencing touchy burdens associated with the grid [1]. Weariness of petroleum derivatives, their perilous effect on condition and an expanding power request brings about an expanded usage of sustainable power sources into the utility grid.

The harmonics in any utility system are generated due to power electronic devices that are used in various vast applications.The harmonics in a system leads to malfunctioning of circuit breakers,flickering of voltage,reduction in power factor and also reduction in efficiency,excess generation of heat in phase conductors,panels and transformers.

The conventional method of reduction of harmonics is the use of LC filters .These LC filters have many disadvantages that include issues related to resonance,size and fixed compensation. Hence active power filters are introduced to overcome the drawbacks that are encounterd in usage of passive filters.

The maintenance of reliable power and power quality is the main consideration in present scenario. In order to maintain reliability of electrical power and improvement of power quality, DG systems plays a key role. Generally, to maintain continuous administration with high quality DG systems are more reliable.

The fuzzy logic controllers are very compatible for many applications.nowadays these have been introduced into power electronics.these will be more advantageous over the regular PI controllers.The Mamdani type of fuzzy filters are more robust than con

ventional PI controllers .these give better results than the conventional PI controllers.but they too have drawbacks as they have large number rules and fuzzy sets.

The basic principle of active power filter is that it draws or supplies the compensating current to cancel out the harmonics. Fuzzy logic controllers are used to evaluate the instantaneous active power and imaginary power and PQ control strategy for approximating the actual currents of shunt active filters for balanced load ,un-balanced load and balanced non-sinusoidal load situations. The control logic consists of fuzzy controller, limitter, three phase sine wave generator for reference current generation and production of switching signals. The maximum value of the current is approximated by controlling the DC link voltage. The capacitor voltage value is related with the set refernce value. The error signal from the comparision is further processed with a fuzzy controller, which gives to zero steady error in following the reference current signal.

The paper is organised as follows. In section 2, the description of the proposed APF system is given. In section 3, the control algorithm of the APF system is explained. The fuzzy inference system is described in section 4. The simulation results are given in section 5 and the interpretation of the results is given. The conclusion and future scope of this work is given in section 6.

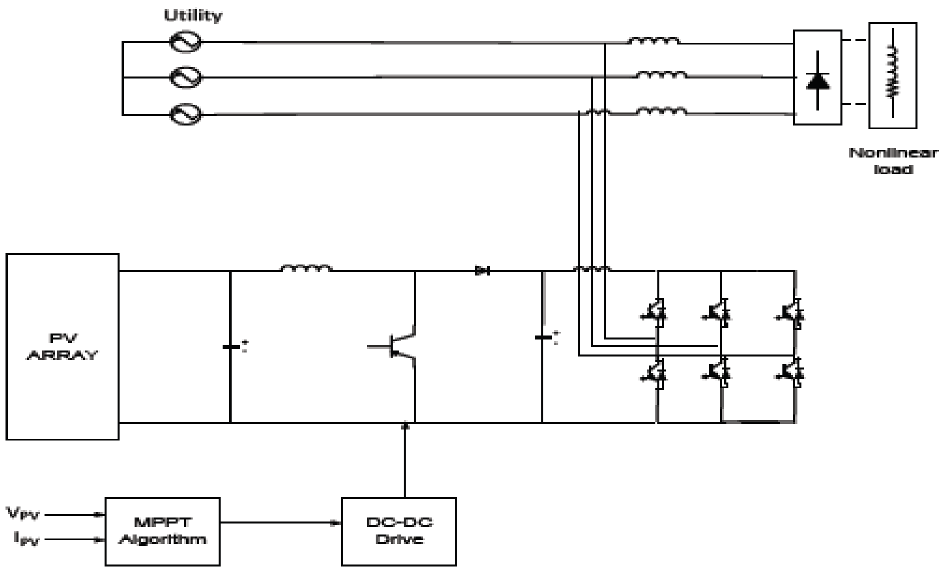

Fig. 1: Proposed PV-APF system

2. Proposed PV-APF System

This paper deals with Grid interconnection system for effective utilization of power generated from PV. The architecture of proposed grid interfaced PV system is shown in figure 1. Along with this an APF controller is introduced in this paper for mitigation of current harmonics produced by non-linear loads.

2.1. Solar System

In photovoltaic (PV) system, solar powered cell is the fundamental segment. Figure 2 appears at a protection yield power trademark bends for the PV exhibit. [5-8].

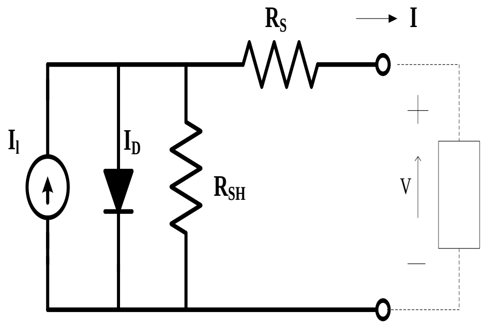

Fig 2: Solar electrical equivalent circuit

2.2. MPPT Technique

Generally, MPPT technique is commonly used for solar and wind systems to maximize system under all conditions. In incremental conductance method, it tracks the incremental changes in PV system voltage and current to predict the effect of change in voltage. INC method can track climate changing conditions than P&O method.

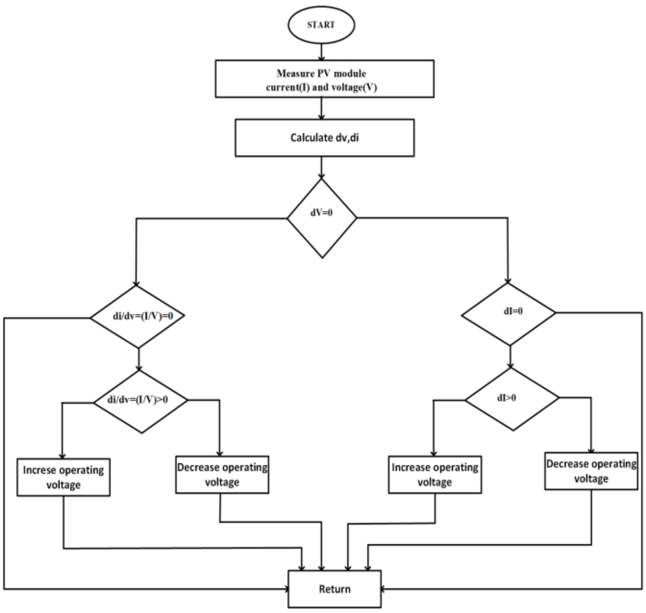

Fig 3: Solar system PV and IV curves

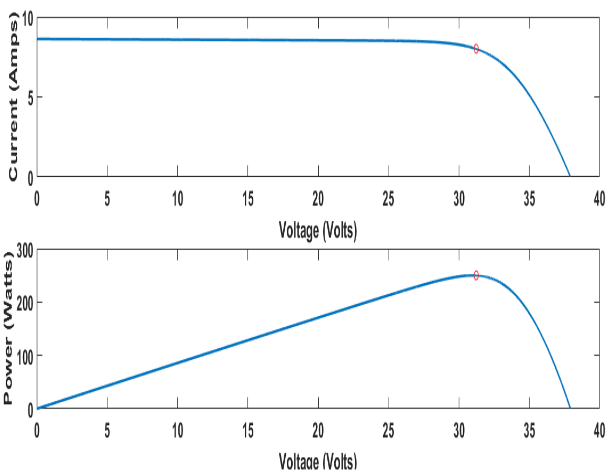

Fig 4: Solar system PV and IV curves

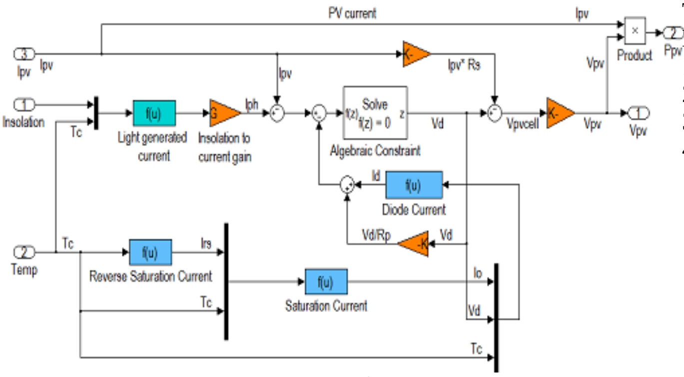

Fig 5: Control diagram for PV system

3. Control System for PV-APF System Using PQ Theory

The main components of the APF system consists of compensating element and three phase converter. PWM based VSC converter is used in PV-APF system. The PWM reference signals required for this converter is generated by using dc link voltages. And harmonic current analysis is implemented using PQ theory.

$$\begin{pmatrix} v_\alpha \\ v_\beta \end{pmatrix} = \sqrt{\frac{2}{3}} \begin{pmatrix} 1 & -1/2 & -1/2 \\ 0 & \sqrt{3/2} & -\sqrt{3/2} \\ 0 & 0 & 0 \end{pmatrix} \begin{pmatrix} v_a \\ v_b \\ v_c \end{pmatrix} \quad (1)$$

$$\begin{pmatrix} i_\alpha \\ i_\beta \end{pmatrix} = \sqrt{\frac{2}{3}} \begin{pmatrix} 1 & -1/2 & -1/2 \\ 0 & \sqrt{3/2} & -\sqrt{3/2} \\ 0 & 0 & 0 \end{pmatrix} \begin{pmatrix} i_a \\ i_b \\ i_c \end{pmatrix} \quad (2)$$

$$\begin{pmatrix} i_{a^*} \\ i_{b^*} \\ i_{c^*} \end{pmatrix} = \sqrt{\frac{2}{3}} \begin{pmatrix} 1 & 0 & 0 \\ -1/2 & \sqrt{3/2} & 0 \\ -1/2 & -\sqrt{3/2} & 0 \end{pmatrix} \begin{pmatrix} i_a \\ i_b \\ i_c \end{pmatrix} \quad (3)$$

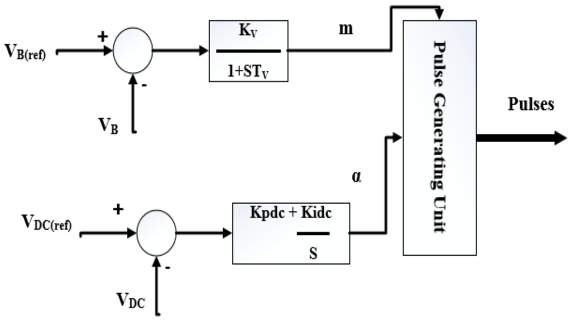

Fig 6: Basic diagram of shunt controller

The shunt controlling circuit is used to send commands to shunt converter. Figure 4, shows the control structure for shunt converter. Modulation index ‘m’ and ‘α’ are considered as the control inputs for shunt converter, where ‘α’ is the angle of voltage injected corresponding to the phase angle of bus to which the controller is connected.

4. Fuzzy Inference System

Generally, Fuzzy Controller is widely used in machine control. The input and output variables in a fuzzy control system are mapped by sets of variables called as membership functions or also called as fuzzy sets.

The process of Fuzzy system is explained under four cases namely:

1. Fuzzification
2. Inference Engine
3. Rule-base formation
4. Defuzzification

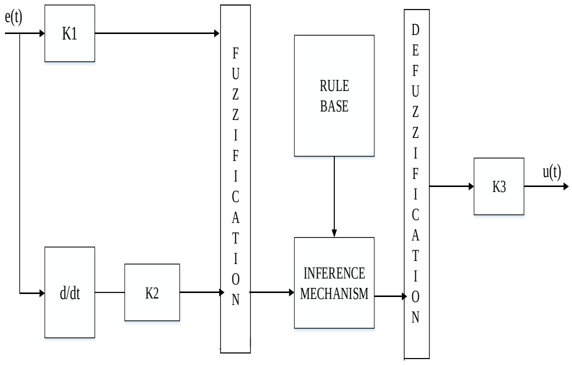

Fig 7: Basic diagram of shunt controller

Fuzzy systems are simple in concept. It consists of three stages called as input stage, processing stage and finally output stage. The input stage identify the input variables and converted into fuzzy sets. The processing stage is used to get the output by using rule base formation.

5. Simulation Results and Discussion

The proposed system is tested and verified by using Matlab/Simulink as shown in figure 1.

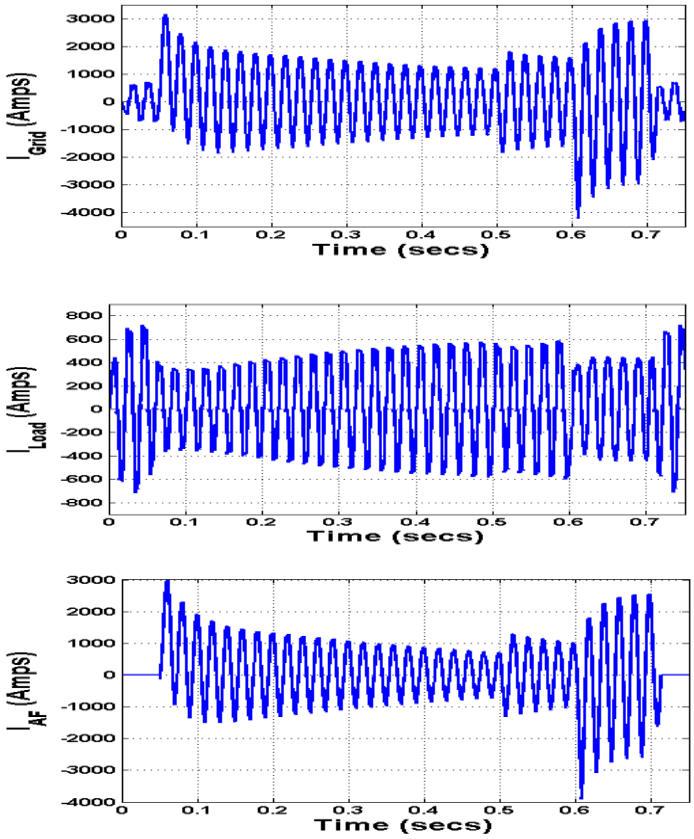

Fig. 8: Results with conventional controller

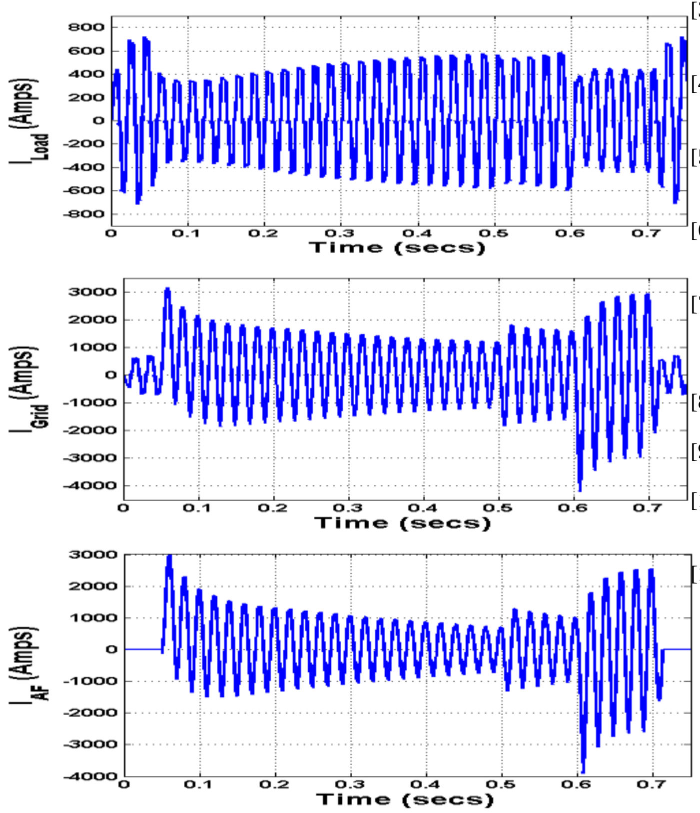

Fig. 9: Results with fuzzy controller

The simulation result for Fuzzy based PV-APF system is shown in Figure 9. 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. As compared with conventional controller, fuzzy controller compensate the better harmonics. The comparison analysis for harmonic analysis under different cases for both fuzzy and conventional controller as shown in below table.

Table 1: Harmonic analysis of both controllers

Modes → Types ↓	Current in d-q axis (0.07s)	Current during PV-APF mode (0.5s)	APF current (0.68s)	Grid current (0.72s)
With PI	3.73	8.4	2.40	15.6
With fuzzy	1.73	3.04	0.18	7.8

6. Conclusion

Finally, a fuzzy based PV-APF controller for grid system is proposed 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 grid to PV system and b) acing as harmonic compensation current between PV system 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.

References

[1] Tuyen, Nguyen Duc, and Goro Fujita. "PV Active Power Filter Combination Supplies Power to Nonlinear Load and Compensates Utility Current", IEEE Power and Energy Technology Systems Journal, 2015.

[2] Villalva MG, Gazoli JR, Filho ER. Comprehensive approach to modeling and simulation of photovoltaic arrays. IEEE Trans Power Electron. 2009; 24(5):1198–208.

[3] Kuo YC, Liang TJ, Chen JF. Novel maximum-power-point tracking controller for photovoltaic energy conversion system. IEEE Trans Ind Electron. 2001; 48(3):594–601.

[4] Houssamo I, Locment F, Sechilariu M. Experimental analysis of impact of MPPT methods on energy efficiency for photovoltaic power systems. Int J Elect Power Energy Syst. 2013; 46:98–107.

[5] Tuyen ND, Fujita **G.** PV-active power filter combination supplies power to nonlinear load and compensates utility current. IEEE Power and

[6] Rezvani F, Mozafari B, Faghihi F. Power quality analysis for photovoltaic system considering unbalanced voltage. Indian Journal of Science and Technology. 2015 Jul; 8(14):1–7.

[7] Kanth KM, Kishore RD. Implementation of MPPT techniques for a high step-up converter with voltage multiplier module based photovoltaic system. Indian Journal of Science and Technology. 2015 Sep; 8(23):1–6.

[8] Das JC. Passive filters-potentialities and limitations. IEEE Trans Ind Appli. 2004; 40(1):232–41.

[9] Akagi H. Active harmonic filters. Proc IEEE. 2005; 93(12):2128–41.

[10] Akagi H, Kanagawa Y, Nabae A. Generalized theory of the instantaneous reactive power in three-phase circuits. Proc Int Conf Power Electron; Tokyo, Japan. 1983. p. 1375–86.

[11] Afonso J, Martins CJ. Active filters with control based on the p-q Theory. IEEE Industrial Electronics Society Newsletter; 2000 Sep. p. 5–10.