Efficient Power Control of Active and Reactive Power in Grid Connected Multi Level PV System using Fuzzy Approach

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Abstract - The grid connected PV system with multilevel inverter gaining attention in the global run for renewable or non - conventional energy sources and the systems utilizing PV modules are motivated from the future benefits of it. The application of PV arrays in the distribution of power as cascaded PV system encounters several obstacles for controlling of output voltage distortions due to over modulation, which results non-uniform behavior of the system. The same need to be controlled using different control methods. In the same context this work proposed a fuzzy based decoupled active and reactive control approach. The proposed method significantly controls the voltage from input to output including reactive and active power and reduces the problems mentioned above. The simulation waveforms clearly show the effectiveness of the proposed method for PV based distribution system.

Keywords - PV System, Cascaded Structure, Fuzzy Logic, over modulation, Active and Reactive Power.

I. INTRODUCTION

Over the past few decades, the demand for renewable energy has increased significantly due to the disadvantages of fossil fuels and greenhouse effect. Among various types of renewable energy sources (RES), solar energy and wind energy have become the most promising and attractive because of advancement in power electronic technique. Photovoltaic (PV) sources are used nowadays in many applications as they own the advantage of being maintenance and pollution free. In the past few years, solar energy sources demand has grown consistently due to the following factors:

1) Increasing efficiency of solar cells;

2) Manufacturing technology improvement;

3) Economies of scale.

Meanwhile, more and more PV modules have been and will be connected to utility grid in many countries. Now the largest PV power plant is more than 100MW all over the world. Furthermore, the output of PV arrays is influenced by solar irradiation and weather conditions. More importantly, high initial cost and limited life span of PV panels make it more critical to extract as much power from them as possible.

As the capacity of PV system growing significantly, the impact of PV modules on power grid can't be ignored. They can cause problems on the grid like flicker, increase of harmonics, and aggravated stability of the power system. To both increase the capacity of PV arrays and maintain power quality, it's necessary to comply with the technique requirements of the PV system, such as fault-ride-through capability and harmonic current regulation. Especially when a large scale PV module is connected to the grid, the effects on the grid may be quite severe. Therefore, the system operation and system stability under fault conditions should be examined when PV modules are interface with power grid.

Increasing use of static power converters like rectifiers and switched mode power supplies causes injection of harmonic currents into the distribution system. Current harmonics produce voltage distortions, current distortions, and unsatisfactory operation of power systems. Therefore, harmonic mitigation plays an essential role in grid-connected PV system.

II. SYSTEM MODEL

The main building blocks of a PV system, shown in Figure 2.1 are described below

PV array

A PV array consists of a number of PV modules or panels. A PV module is an assembly of a large number of interconnected PV cells.

Inverter

The inverter in a PV system is utilized to change the DC-voltage delivered from a PV module to a three-phase AC voltage. A three-phase inverter has three legs with two switches in every leg. The exchanging is performed via transporter based or space-vector-based Pulse-Width Modulation (PWM). A point by point dialog on various inverter topologies is given later in this section. The inverter is generally interfaced to the utility grid through a transformer. In any case, transformer-less PV inverter topologies have likewise been proposed and executed for single-phase grid-associated PV inverter.

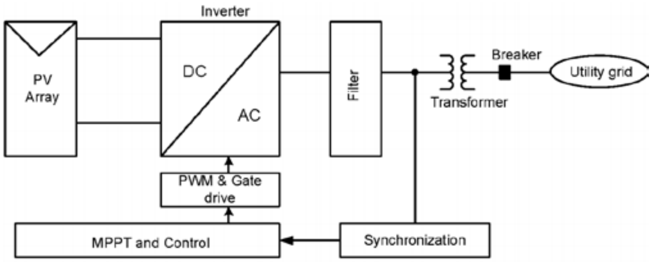

Figure 2.1 Structure of a typical single-stage PV system.

Filter

The output amount of an inverter (voltage in VSI and current in CSI) is beat and contains switching harmonics alongside a 60 Hz central. Keeping in mind the end goal to isolate the 60 Hz part, a filter is basic at the AC terminal of the inverter, where it is interfaced to the grid.

Since the performance of the filter depends on the grid impedance, special care must be practiced in the filter design.

III. PROPOSED MODEL

The proposed model of grid connected multilevel PV system is explained in below figures. The system is equipped with the fuzzy logic controller to enhance the quality of power and reduce the fluctuations as possible as it can be. The improved results are shown in the simulation results.

Fig. 3.1 shows the main model of the system and the inside connections among sub blocks are shown in the sub system blocks. Different levels are shown inside the phases and each modulate has on PV system with fuzzy logic controller and other functioning.

Fig. 3.2 shows the multi level module of the system which is present in each phase of the system. In Fig. 3.3 shows the PV with fuzzy logic controller as a subsystem is shown. Fig. 3.4 shows the fuzzy logic controller.

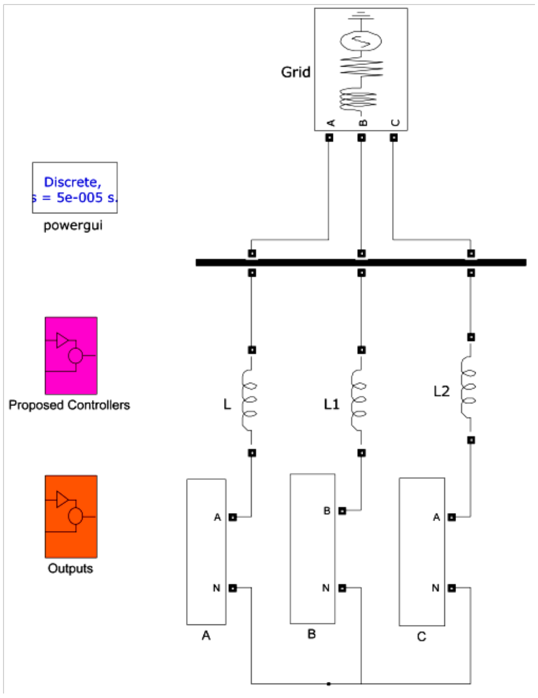

Fig. 3.1 Simulink Main Model of Proposed Methodology

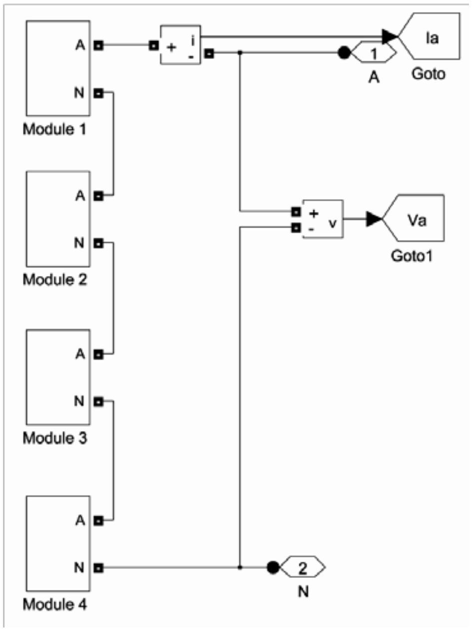

Fig. 3.2 Simulink Model of Multi-level Modules

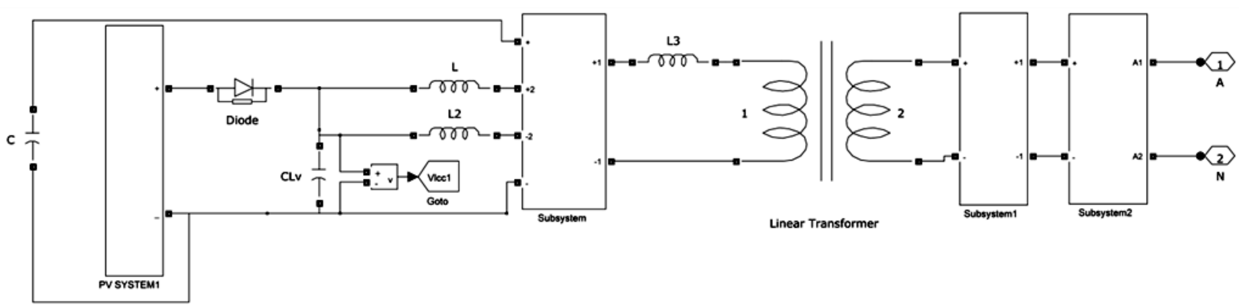

Fig. 3.3 Simulink Model of PV System

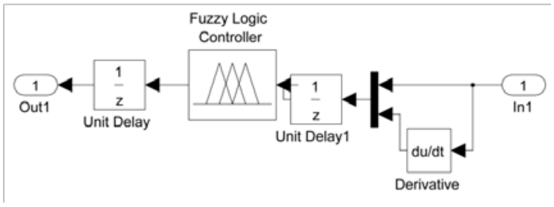

Fig. 3.4 Simulink Model of Fuzzy Controller

The fuzzy controller block utilizes the fuzzy rules created under mamdani model and are stored in the .fis files with the system, and it needs to be import into the MATLAB workspace to access inside the controller. In the absence of these rules system creates block error while simulation.

The .fis file can be opened in the fuzzy editor toolbox, which can be opened by typing the "fuzzy" into the command window of MATLAB.

IV. SIMULATION OUTCOMES

The above mentioned system with proposed methodology is explained with each sub modules and the sub systems.

The simulation is performed for two seconds and the waveforms of the different parameters are shown in the below figures.

Fig. 4.1 shows the single phase characteristics(waveforms) of the proposed system where it shows the grid power, second waveform is of PV array irradiation, third waveform shows active power of PV module, then reactive power of PV module followed by DC current and DC voltage. From these waveform one can analyze that the performance of the system is better than the previous results and can have improved reliability.

The waveforms has lesser number of fluctuations than the previous waveforms. Fig. 4.2 shows the zoomed waveforms of given waveforms from 1.44 to 1.56 seconds.

Fig. 4.3 shows the waveforms of three phase grid connected PV system. The figure shows the waveform of three phase grid voltage, grid current, followed by active power of the grid and reactive power to grid. After that the DC voltage of Phase A, Phase B and Phase C.

Fig. 4.4 shoes the zoomed waveforms of Fig. 4.3 from 1.48 to 1.6 secs.

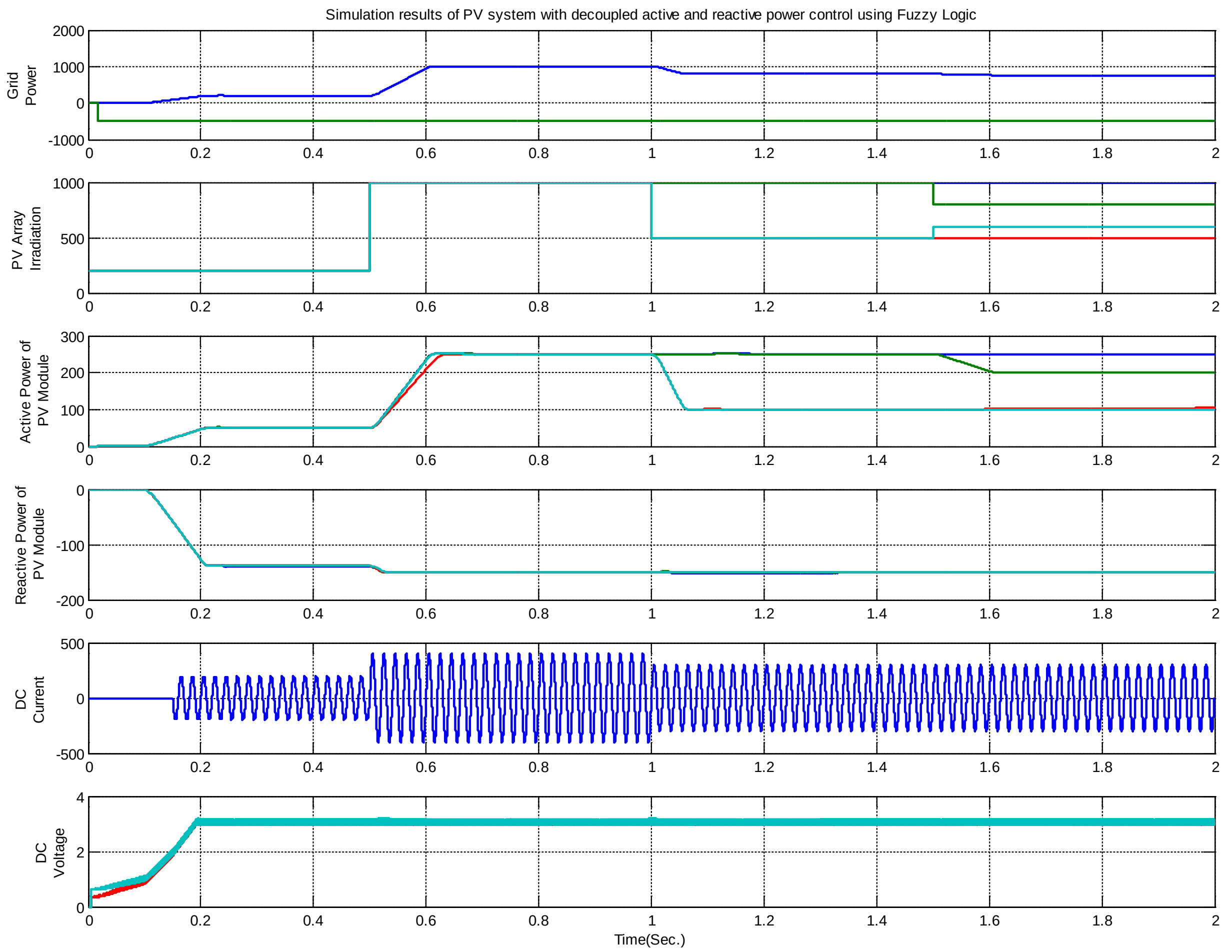

Fig. 4.1 Simulation Results of Proposed Decoupled Multilevel Grid Connected PV System of Single Phase (phase a)

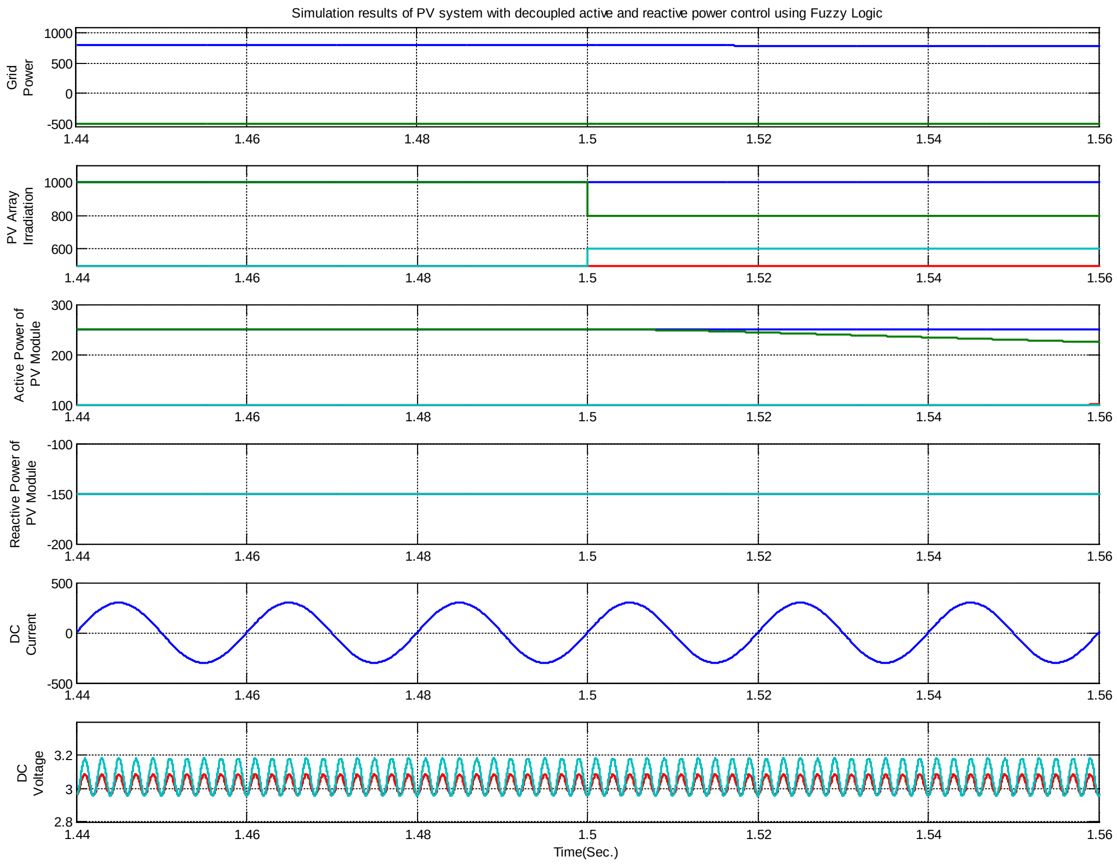

Fig. 4.2 Simulation Results of Proposed Decoupled Multilevel Grid Connected PV System of Single Phase (Zoomed at 1.5 sec.)

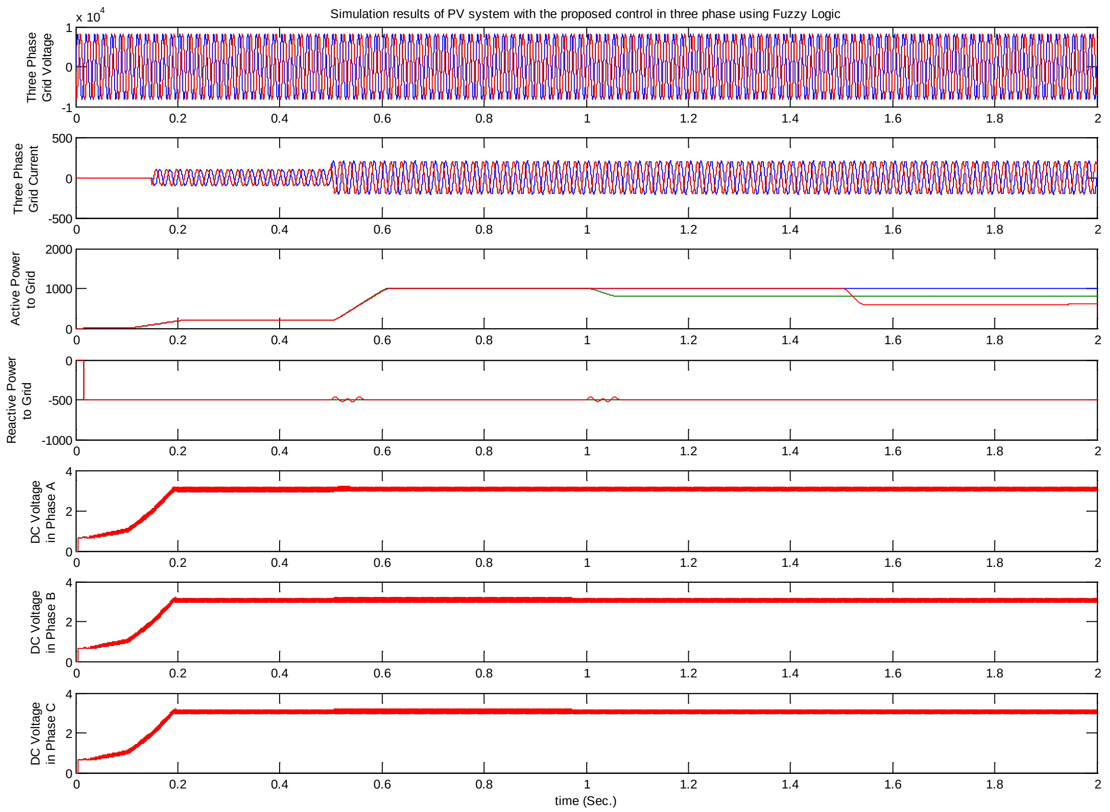

Fig. 4.3 Simulation Results of Proposed Decoupled Multilevel Grid Connected PV System of Three Phase

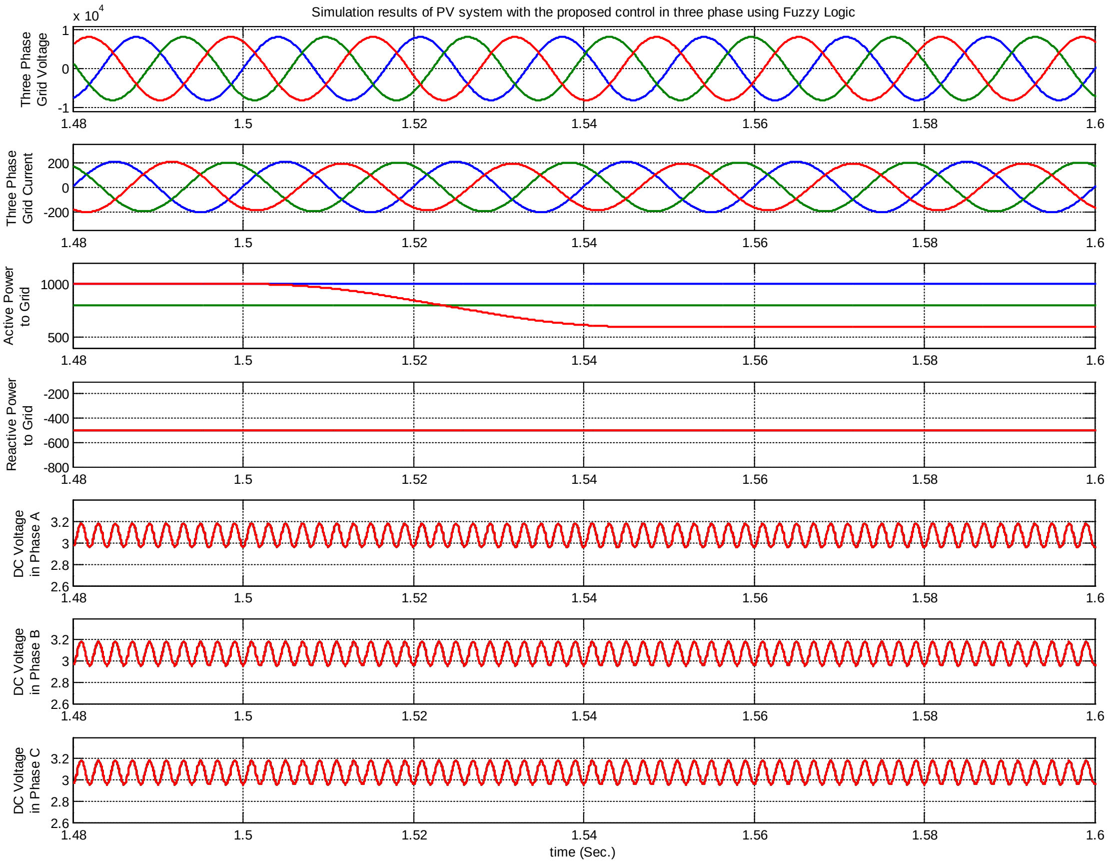

Fig. 4.4 Simulation Results of Proposed Decoupled Multilevel Grid Connected PV System of Three Phase (Zoomed at 1.5 sec.)

V. CONCLUSION AND FUTURE SCOPE

The work explained in here is to focus on the non-conventional source of energy and the system dealing to regulate the power received from the system and some of the aspects are simulated and analyzed in this work. The voltages and currents of different modules are taken into consideration to control the power at the load side with the help of fuzzy logic. The active and reactive power control developed on the continuous simulation basis and after calibration in the fuzzy set rules the improved waveforms are achieved. The zoomed waveforms clearly shows the improvements in the efficiency and performance over existing system. In the near future for further improvements other controlling techniques like PID controlling or integrated form of different soft computing techniques will help.

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