Solar Energy Conversion System using Ripple free MPPT for Grid connected PV system

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Abstract — **This project presents a control methodology of three phase grid connected PV system and its control schemes for applications in distributed generation (DG) systems. The system utilizes a two stage energy conversion topology composed of a DC-DC boost converter and five level-three phase voltage source inverter (VSI). The DC-DC converter is used to extract maximum power from the PV array and boost its output voltage. A maximum power point tracking (MPPT) technique is proposed in which hysteresis algorithm is used, with direct control method in which duty cycle is adjusted to achieve the maximum power point (MPP). The VSI is used for converting the maximum power extracted by DC-DC converter to AC power by giving the gate pulse from voltage source controller. Simulation results on MATLAB/Simulink software are carried out to confirm the system operation. The Efficiency of MPPT and DC link voltage on the entire PV system is increased.**

Keywords— **Maximum power point tracking (**MPPT**),DC-DC converter, Voltage source inverter(VSI), Distributed Generation.**

I. INTRODUCTION

Photovoltaic (PV) energy has become one of the most popular sustainable energy sources nowadays. Due to continuous cost reduction and government incentives, the installation of grid-integrated PV system has grown rapidly in the past few years. The search for renewable energy sources then becomes more and more intense as a prominent alternative for the mitigation of the world energy crisis. Among the clean and green power sources, the photovoltaic (PV) solar energy comes up as an interesting alternative to supplement the generation of electricity.

In MW-scale high-voltage grid-tied PV systems, galvanic isolation between the PV panel and the grid is required to prevent electric shock on PV panel due to insulation damage and to suppress leakage current. Around 75% of the PV systems installed in the world are grid connected. In the grid-connected PV system, DC-AC converters (inverters) need to realize the grid interconnection, inverting the dc current that comes from the PV array into a sinusoidal waveform synchronized with the utility grid besides, the DC-AC converter is used to stabilize the dc-bus voltage to a specific value, because the output voltage of the PV array varies with temperature, irradiance, and the effect of MPPT (maximum power point tracking).The high efficiency is one of the most important characteristics of a PV inverter.

Grid-connected PV systems because the solar irradiance and temperature change throughout the day, as well as along seasons and geographical conditions, also leading to the modification of the (current versus voltage) and (power versus voltage) curves of the PV module. The conversion efficiency is low and the initial cost is still appreciable, as it is necessary to use MPPT techniques in order to maximize the extracted energy. It is important to emphasize that there is only one MPP for each curve at given temperature and irradiance levels.

MPPT techniques widely known in the literature by using a dc-dc boost converter operating in continuous conduction mode to supply a given load. If this voltage ripple propagates to the PV side, it will deteriorate the MPPT performance and decrease the MPPT efficiency. All the control, MPPT, and grid-current are implemented in the DC-AC stage (inverter) that consists of a three-phase bidirectional power flow PWM voltage source inverter (VSI).This is the principal power electronics circuit of a Three-Phase Grid-Connected PV Power System. The MPPT will not be carried out by a DC-DC stage; it will be performed by the inverter, which is also responsible for the grid-current control. And the super capacitor is used to reduce the ripples.

II. LITERATURE REVIEW

A. Liming Liu, Hui Li, Senior Member, IEEE, Yaosuo Xue, Wenxin Liu, "Reactive power compensation and optimization strategy for Grid-interactive cascaded photovoltaic systems", IEEE Transactions on Power Electronics,2014.

Cascaded multilevel converter structure can be appealing for high power solar photovoltaic (PV) systems to its modularity, scalability, and distributed maximum power point tracking (MPPT). However, the power mismatch from cascaded individual PV converter modules can bring in voltage and system operation issues. This paper addresses these issues, explores the effect sof reactive power compensation and optimization on system reliability and power quality, and proposes coordinated active and reactive power distribution to mitigate this issue. A vector method is firstly developed to illustrate the principle of power distribution. Accordingly, the relationship between power and voltage is analysed with a wide operation range. Then an optimized reactive power compensation algorithm is proposed to improve the system operations stability and reliability, and facilitate MPPT implementation for each converter module simultaneously.

B.Charles R.Sullivan, Jonathan J.Awerbuch, and Alexander M.Latham, "Decrease in Photovoltaic Power Output from Ripple: Simple general calculation and the effect of partial shading", IEEE Transactions on Power Electronics Vol. 28, No. 2, February 2013.

The effect of voltage ripple on the power output of a photovoltaic panel is calculated and tested experimentally. Voltage ripple induces a much larger power reduction than would be predicted from a conventional small-signal model of the panel's **I**–V characteristic, even with small ripple amplitude. A simple expression is provided to calculate power reduction from RMS ripple voltage, for any ripple wave form shape. The effect of ripple on power output can be much more severe under non uniform irradiance as can result from partial shading.

C. Xiao hu Liu, Hui Li, Senior Member, IEEE, and Zhan Wang, "A Fuel Cell Power Conditioning System With Low-Frequency Ripple Free Input Current Using A Control-Oriented Power Pulsation Decoupling Strategy", IEEE Transactions on Power Electronics Vol. 29, No. 1, January 2014.

This paper proposes a fuel cell power conditioning system based on the current fed dual half bridge (CF-DHB) dc–dc converter that can achieve low-frequency ripple-free input current using a control oriented power pulsation decoupling strategy when an inverter load is connected to the fuel cell system. Without adding any extra circuit components, theproposedpowerpulsationdecouplingstrategycanrealizeasmal lerdcbuscapacitor; a film capacitor, therefore, can be applied in this fuel cell power conditioning system to replace the bulky electrolytic capacitor. In order to eliminate the double frequency ripple current disturbance introduced by the inverter load to the fuel cell stack, a proportional resonant controller is developed to achieve an extra high control gain ata designed resonant frequency. The operation principles of the CF-DHB converter with a proposed power pulsation decoupling strategy are analysed.

III. CHARACTERISTICS OF SOLAR CELLS

Solar cells are basically p–n junction semiconductors which transform solar energy into electricity directly. Fig. 1 shows an equivalent circuit of a solar cell [2], in which R_{sh} and R_S are the intrinsic shunt and serial resistors of the cell, respectively. A current source I_{ph} represents the cell photocurrent, which is a function of illumination S_i and solar array temperature T, and can be expressed as follows:

$$I_{ph}=[I_{sso}+K_i(T-T_r)]S_i/100 \qquad (1)$$

where I_{sso} is the short-circuit current at reference temperature T_r and reference illumination (100mW/cm^2), and K_i is temperature coefficient of the short-circuit current.

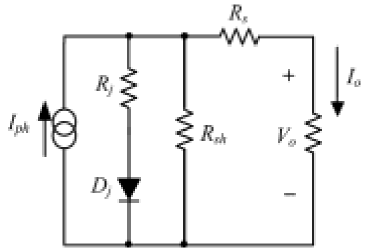


Figure. 1. Equivalent circuit of a solar cell.

IV. PROPOSED SYSTEM

The proposed design dc–dc converter presents the following features.

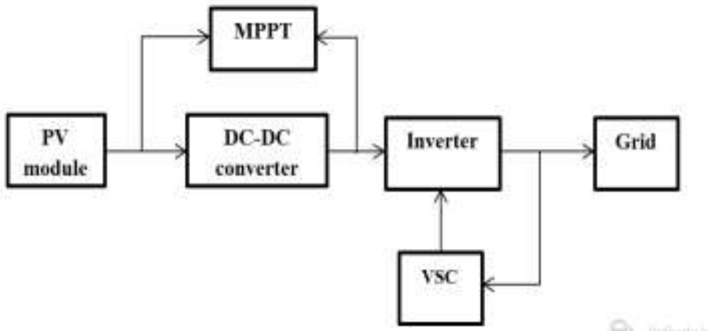


Figure 2 Block Diagram of Proposed System

Low number of active devices compared to the converters usually applied to reduce switching losses, DC - DC converter is essential equipment in the system of DC load which has a function as step up and step down voltage. A dc-to-dc converter is required electrical couple to the system dc load. Dual active bridge DC-DC converters are mainly used for renewable energy applications. In the full bridge DC-AC-DC converter which allows energy transfer between the source and the load. A high frequency transformer is used as isolation in DC-DC full bride converter. Various modulation strategies have been discussed for the dual active bridge DC-DC converter.

Compared to voltage-fed converters, current-fed converters have lower input current ripple, lower HF transformer turns ratio, negligible diode ringing, and easier current control ability .Therefore, current-fed converters are meritorious for low voltage and high current application. The major limitations of current-fed converters are hard switching and snubber requirements to absorb the switch turn-off voltage spike.

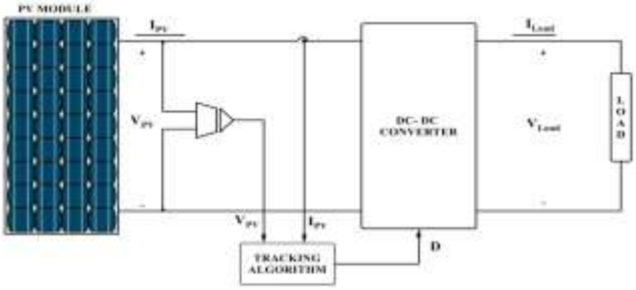


Figure 3 DC-DC Converter with the PV Interface

V. SIMULATION MODEL OF PROPOSED SYSTEM

In this model the PV panel is connected with grid system. Due to the irradiation problems a sufficient power will not obtained. Implementation of hysteresis algorithm is required to overcome this problem. The gate pulse has been generated by connecting a voltage source inverter with the system.

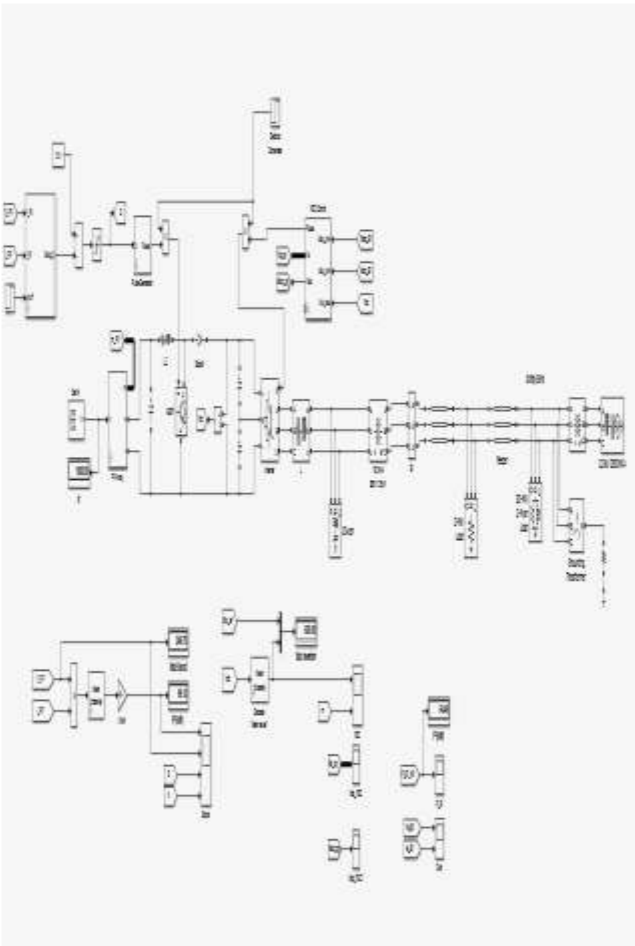
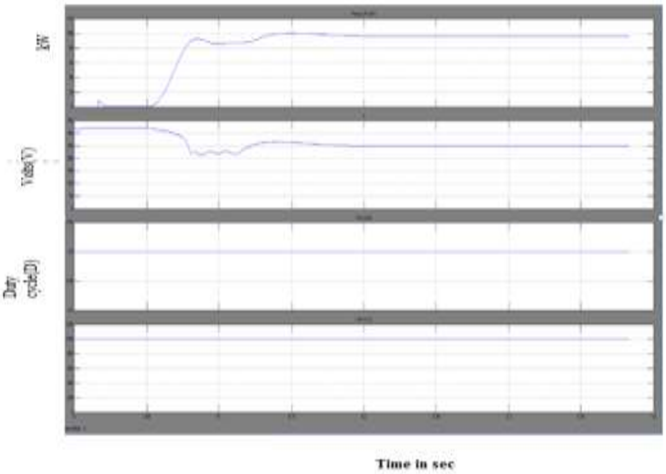


Figure 4 Simulation model of proposed system

VI. SIMULATION RESULTS

PV Input Power, Voltage, and Irradiation



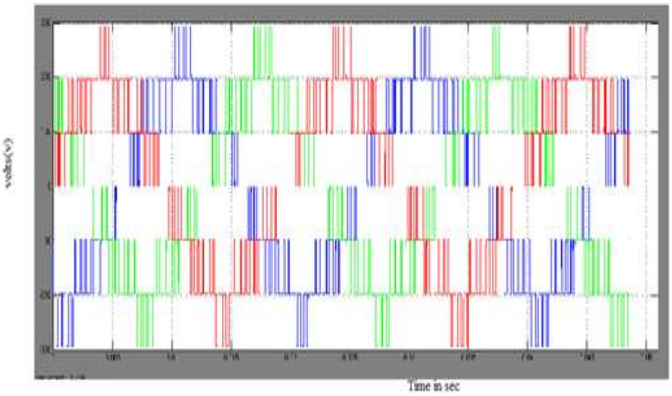


Figure 5 Three phase inverter output voltage

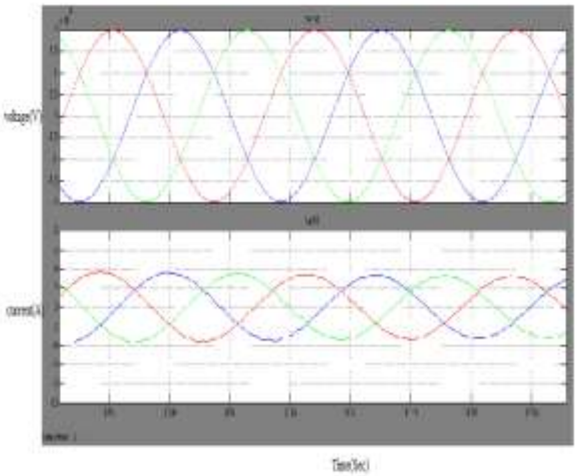


Figure 6 Grid Voltages and Current

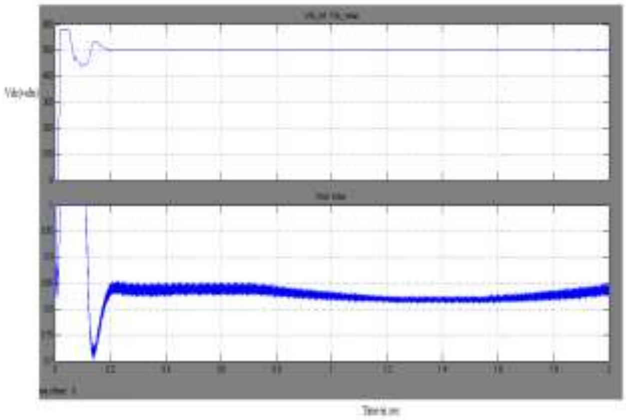


Figure 7 MPPT output voltage and modulation index

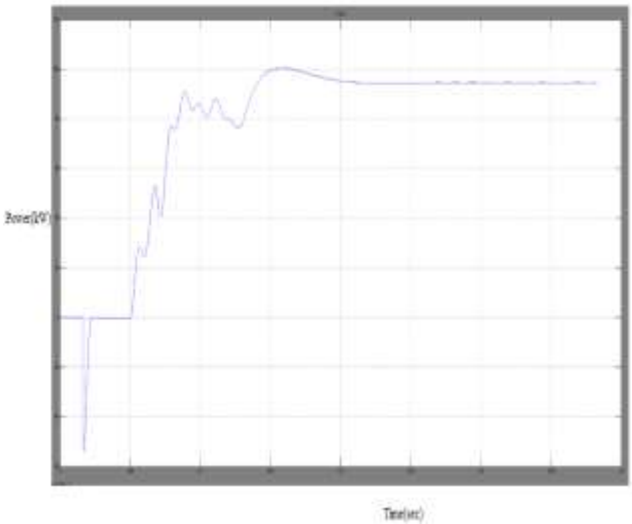


Figure 8 Inverter output Power

VI. Conclusions

In this project is grid-tied Multilevel inverter PV system based on dc-dc converters using hysteresis control has been proposed. The contribution of the project is to generate the multilevel power generation. A detailed low-frequency power mitigation control for the Boost converter was proposed based on the dynamic model of the converter. With the proposed using hysteresis controller algorithm, the large low-frequency voltage ripple on the dc-link can be blocked away from the PV side. This proposed power mitigation control can be extended to other boost converter output to the grid. Hysteresis current control MPPT method was also proposed. Fast tracking speed under rapid irradiation change and high MPPT efficiency were realized for the PV system.

References

1. S. Harb, and R. S. Balog, "Reliability of candidate photovoltaic module-integrated-inverter (PV-MII) topologies - A usage model approach," *IEEE Trans. Power Electron.*, vol. 28, no. 6, pp. 3019-3027, Jun. 2013.
2. H. Hu , S. Harb , N. Kutkut , I. Batarseh and Z. John Shen, "Power decoupling techniques for micro-inverters in PV systems-a review," in *Proc IEEE Energy Convers. Congr. Expo*., Sep. 2010, pp. 3235-3240
3. G. Petrone, G. Spagnuolo, R. Teodorescu, M. Veerachary and M. Vitelli, "Reliability issues in photovoltaic power processing systems," *IEEE Trans. Ind. Electron*., vol.55, no.7, pp. 2569-2580. Jul. 2008.
4. S. B. Kjaer, J. K. Pedersen, and F. Blaabjerg, "A review of single-phase grid-connected inverters for photovoltaic modules," *IEEE Trans. Ind. Appl*., vol. 41, no. 5, pp. 1292-1306, Sep./Oct. 2005
5. C. Sullivan, J. Awerbuch, and A. Latham, "Decrease in photovoltaic power output from ripple: Simple general calculation and the effect of partial shading," *IEEE Trans. Power Electron*, vol. 28, pp. 740-747, Feb. 2013.
6. N. Femia , G. Petrone , G. Spagnuolo and M. Vitelli "A technique for improving P&O MPPT performances of double-stage grid-connected photovoltaic systems", *IEEE Trans. Ind. Electron*., vol. 56, no. 11, pp. 4473-4482, Nov. 2009.
7. Trishan Esram and Patrick L. Chapman; "Comparison of PhotovoltaicArray Maximum Power Point Tracking Techniques," *IEEE Trans on Energy Conversion*, Vol. 22, No. 2, pp. 439-449,June, 2007.

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