DESIGNING & ANALYSIS OF MICRO INVERTER FOR PV GRID

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Abstract -*There is a critical need to make use of renewable energy sources such as solar energy to Develop efficient and economical solutions to the energy crisis that many countries are facing. This need is worsened in developing countries by the resented of weak or unreliable electrical grids. A popular solution is the use of solar based single phase micro- inverters feeding AC power to the grid. We will present an improved PWM inverter control system that can be applied in grid-connected PV generation and uses MATLAB / Simulink software to simulate and analyze. The result of the simulation shows that the improved inverter control system can effectively control the grid current waveform which tends to sine wave, meanwhile it can achieve the maximum power point tracking, besides it is able to put the arbitrary power out to the load or to the grid, while the control system has a good stability*

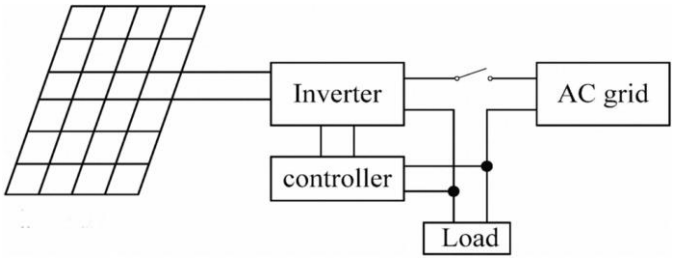
***Key Words*: Micro-inverter, Controller, AC grid, Solar PV grid, PWM control skim**

1. INTRODUCTION

With the increasingly urgent energy issues, the world attach great importance to begin the development of new energy and related technology. At present, large-scale photo voltaic power generation and scale of renewable energy has become important parts of development strategy, mean while it is the way to guide the development of photo voltaic industry. However, because of its own characteristics different from conventional power generation ,grid-connected PV power station and its security, stability, reliable operation became new challenges which power grid.

The paper describes two inverter control methods including the voltage source inverter control method and the power type PWM inverter control method which are common used at present. Voltage source inverter control method regulates phase angle of the grid mainly through receiving voltage signals from DC side of inverter which is called the outer loop to control the grid voltage, while it regulates the voltage reference from the AC side load voltage to control the inverter output current which is called the inner loop. However, the process of the inner loop will not affect the results of the outer loop. Power-type PWM inverter bridge circuit formed by the two groups, which uses two reverse diodes synchronized transformation. Required power can be got by changing the modulation rate of PWM inverter.

Therefore, whether the grid-connected PV generation inverter control system is able to achieve the maximum power point tracking(MPPT) and to ensure high power quality of the photovoltaic cells or not are the key issues in electric power system.



The inverter device with the function of maximum power point tracking can inverse the electric power into sinusoidal current, and connect to the grid. The control system mainly control the maximum power point tracking of photovoltaic, current waveform and power of the output of grid-connected inverter, which makes the output to the grid correspond with the export by PV array.

2. PAPER REVIEWED

Yanfeng Shen, Huai Wang, and Frede Blaabjerg at [1] have performed on Reliability Oriented Design of a Grid-Connected Photovoltaic Micro inverter. High reliability performance of micro inverters in Photovoltaic (PV) systems is a merit to match lifetime with PV panels, and to reduce the required maintenance efforts and costs. This paper applies a reliability oriented design method for a grid connected PV micro- inverter to achieve specific lifetime requirement. Reliability allocation is performed from the system level requirement to the component-level reliability design target. Special attentions are paid to reliability-critical components, e.g., GaN HEMTs and the dc-link aluminum electrolytic capacitor. A design flow chart, including key steps of mission profile based long-term stress analysis, lifetime predication, and reliability modeling is presented. A case study of a 300 W two-stage PV micro inverter is used to demonstrate the design method.

Prakash Kumar Dewangan, U .T. Nagdeve at [2] have performed on Review Of An Inverter For Grid Connected Photovoltaic (PV) Generation System The review of inverter is developed with focus on low cost, high reliability and mass production for converting electrical energy from the pv

module to the grid. Various inverter topologies are presented, compared, and evaluated against demands, lifetime, component ratings, and cost. Inverter based PV system to explain electrical performance subjected to different operating conditions. Multilevel inverter is one of the most recent and popular type of inverter founds its applications in the system based on renewable energy. This paper describes a new Single-phase Eleven level inverter topology for solar photovoltaic (PV) system using a carrier based PWM control scheme. This new topology has reduced number of switches for an increased number of levels when compared to conventional seven- level inverter. Here PWM switching scheme is used to control the switches in this multilevel inverter and this inverter is fed from a solar PV. By using this inverter topology, the harmonics is reduced and efficiency is enhanced significantly.

H. S. Bae, S. J. Lee, K. S. Choi and Bo H. Cho S. S. Jang at [3] have performed on Current Control Design for a Grid Connected Photovoltaic/Fuel Cell DC-AC Inverter In this paper, a current controller design method for a DC-AC inverter in a grid connected photovoltaic or fuel cell power conditioning system (PCS) is proposed. A state feedback current controller using a sine reference function tracking algorithm and I-P(Integral Proportional) outer DC- link voltage controller using a 120Hz notch filter are proposed to control the output current to be in-phase with the grid voltage and to regulate the input DC link voltage. Since the analysis and design are performed in the time domain using the state equations, the current loop controller can be systematically designed for the required system specification using the pole placement technique. Also, the 120Hz notch filter for DC- link voltage regulation can enhance the dynamic performance by increasing the voltage loop bandwidth. The design guideline of each controller is provided using the stability analysis. For a design example, the prototype two-stage PCS hardware with a TMS320F2812 DSP and a real 200W solar array has been experimented to validate the proposed digital control scheme.

H. Koniki, P. Bajpai at [4] have performed on Central and Micro Inverters for Solar Photovoltaic Integration in AC grid This paper presents detailed modeling of central inverter and micro inverter for solar photovoltaic (PV) integration in AC grid. Data of a 100 kW solar PV plant installed in IIT Kharagpur is used to validate these models and their performance on sunny, cloudy and partially shaded days are compared. Models of 5 kW grid tie central inverter and 250 W micro inverter are developed with polycrystalline solar PV in MATLAB/Simulink. solar irradiance and PV module temperature data are taken from SCADA system from that actual solar PV plant as inputs to the simulation models. Comparative results are captured in terms of inverter AC power output under different operating conditions and the solar PV system with micro inverters have illustrated better performance compared to central inverter.

Cheng Chen, Student, Qing Xie at [5] have performed on Research of An Improved Grid-connected PV Generation Inverter Control system The paper firstly introduces the structure and operational principle of the present grid-connected PV generation system. And then describes the two inverter control. methods including the voltage source inverter control method and the power type PWM inverter control method which are common used at present. Based on the above two kinds of inverter control methods, the second step is to present an improved PWM inverter control system that can be applied in grid-connected PV generation. Finally, it constructs a single-phase grid-connected PV generation system, and uses MATLAB/Simulink software to simulate and analyze. The result of the simulation shows that the improved inverter control system can effectively control the grid current waveform which tends to sine wave, meanwhile it can achieve the maximum power point tracking, besides it is able to put the arbitrary power out to the load or to the grid, while the control system has a good stability

Madhuwanti Joshi*,Vivek Agarwal**, Siddhesh Shinde at [6]. A Low Cost Bi-Directional Grid Tied Solar PV Micro inverter This paper presents a new micro- inverter topology focused for the cost driven market in the developing countries. This topology is based on the series loaded resonant converter and synchronous rectifiers to allow the bi-directional power flow between the PV source and grid. The main advantages of this topology are as follows: (1) Low cost; (2) Low component count;(3) Bi-directional power flow capability to support reactive power and (4) High semiconductor integration. The proposed topology has the potential for high efficiency energy conversion with component optimization. A 300 Watt laboratory prototype of the topology has been designed, built and tested. Experimental results show that the proposed topology can realize very simple design and is particularly suitable for high voltage (with MPP voltage range of 50 to 60V) low current PV panels.

Naila Ramzan, Zeinab Jamal Khan, Palwasha Naseer, Arooj Akbar,Nauman Zaffar at [7] have performed on Grid Tied Solar Micro-Converter with Optimizer-Mode Operation for Weak-Grid Operation. There is a critical need to make use of renewable energy sources such as solar energy to develop efficient and economical solutions to the energy crisis that many countries are facing. This need is worsened in developing countries by the presence of weak or unreliable electrical grids. A popular solution is the use of solar based single phase micro- inverters feeding AC power to the grid. However, they require a stable grid and input current pulsation at twice the line frequency is an inherent disadvantage. This limitation is typically remedied by a large electrolytic input capacitor that increases the cost and reduces the efficiency of the converter. This paper therefore proposes a dual mode fly back based hybrid converter that can support both a grid tied mode and islanded mode operation to extract maximum power from the solar PV source at all times. It is also designed to employ active power decoupling to draw constant input current with reduced filter size at the terminals of the PV panel in both AC and DC output power modes.

The ability of the proposed converter to produce both DC and AC output allows flexibility of operation in environments where the grid may not be available for as high as 80% of sunlight hours while maintaining the advantages of micro-inverters. This paper presents the analysis, P-SIM simulation as well as the experimental validation of the proposed converter system on a 240 watt prototype. The results obtained validate that this approach can be applied to large distributed generation networks of micro inverters in weak grid communities.

3. OBJECTIVES OF MODELING OF MICRO INVERTER

Solar micro inverter is modeled as per data sheet of Repulse-250. Micro inverter comprises of fly-back converter and single phase full bridge inverter. Micro inverter schematic diagram is shown in *Fig. 5*. To reduce the size of inverter and introduce high voltage gain a high frequency isolator transformer are used.

When the switch *Q1* (MOSFET) is ON, energy from PV is stored in magnetizing inductor of transformer. When diode *D1* conducts, stored energy from inductor is transferred to full bridge inverter. In fly-back converter, inductor voltage and current are scaled according to 1: *n* turns ratio of the high frequency isolator transformer.

Turns ratio *n* is calculated by input and output voltages of fly back converter. The magnetizing reactor is found out considering 1% current ripple and switching frequency 150 kHz. Input capacitor *Cin** is evaluated by taking voltage and current ripple 5% and 1% respectively. DC link capacitor *Cdclink** is calculated considering power transfer to single phase inverter. PI controller is utilized to generate duty ratio from change of input voltage for fly-back converter. Parameters of fly-back converter.

3.1 Fly-Back Converter

The ease, straightforwardness of configuration and inherent efficiency of fly back transformers have made them a prevalent answer for power supply outlines of beneath 100W to 150W. Different favorable circumstances of the fly back transformer over circuits with comparable topology incorporate disengagement in the middle of primary and secondary and the capacity to give numerous outputs and a decision of positive or negative voltage for the yield.

4. METHODOLOGY

1. Select the inverter topologies.
2. The main specifications are: PV module voltage is the range from 23 V to 50 V. Maximum PV power is equal to 160 W. The RMS value of the grid.
3. voltage is 253 V, and the power factor shall be 0.95. For selection the inverter topologies depends on electrical specification such as cable, electrolytic capacitor, silicon device, and magnetic.

4. A. PV connected DC-DC converter- The inverter is made up input capacitor, four MOSFETS with freewheeling diode, high frequency transformer.
5. B. Grid connected DC-AC inverter-The inverter is made up a dc link capacitor, four MOSFETS with freewheeling diode, and LCL filter(the stability of the system is evaluated with filter.

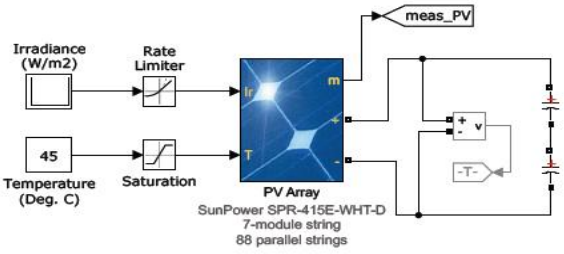
4.1 Power type PWM inverter control method

It is composed of two bridge circuits having two reverse diodes to carry out synchronous transformation. It applies discontinuous current manipulating technique to increase or decrease output voltage of PV, getting needed power which will be controlled through changing modulation rate of PWM. For one thing, it is unrelated with the delivery voltage of PV cells, it can put arbitrary power out to the load or system, for another, the value of power factor is high due to the control signal is in phase with the system. Finally, the circuit structure is simple and the cost is low. The greatest advantage of power type PWM inverter is that it can put power overall to the system. First of all, it should set the input signal Ui and the grid voltage each to the same phase when PV system connect with grid, and then Ui drive PWM power type inverter, getting the output voltage.

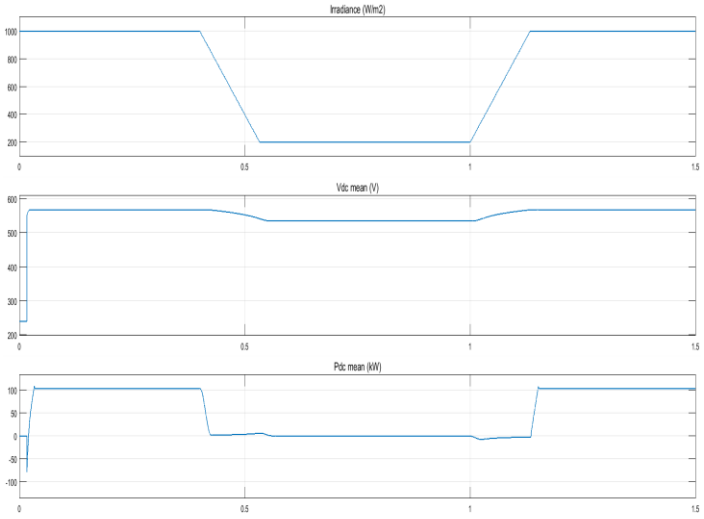
4.2 Improved PWM inverter control method

In improved PWM inverter control method the two reverse diodes used in power type PWM is removed. And the setting of the drive voltage phase of the inverter is based on the grid voltage phase which means the output power factor will be kept to a high value. The improved PWM inverter control system also use the outer loop to control voltage and the inner loop to control current which is the same with the voltage source inverter control, and then it tracks the maximum power point after using the output current transforms to a fit type, which can ensure maximum power output of the battery. In this way, the system inverter structure is simpler than the power-type PWM, and ensures the stability of the power output. The improved PWM inverter circuit can realize the following mode. For one thing, work as AC switch. This improved type PWM inverter control method adopted the isolated transformer to allow the load to achieve the required voltage, which plays an important role of separating AC system from DC system.

SIMULATION CKT



WAVEFORM



5. CONCLUSION

The proposed design of single phase grid connected inverter system has been analyzed and simulated by using MATLAB/SIMULINK. The output of solar PV power generation system is used to inject a power into the utility grid It saves the fossil fuels from depletion, limits global warming and keeps the environment clean The 60V voltage generated by PV array is stepped up to 400V DC voltage using a Flyback converter with a switching frequency of 50KHz. Flyback converter is also used for isolation purpose of primary to secondary sides. The 400V DC output voltage of Flyback converter is converted to 240V AC voltage using inverter. The switching frequency of inverter is 15 KHz. Thus a 240V AC voltage is produced which can be directly used by loads.

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