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Single Phase Module Integrated Converter Topology for Microgrid Network

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Abstract: The centralized approach of the traditional power grid would leads to national power blackout resulting in research for alternate solutions. This effort leads to the concept of smart grid. The single phase PV panel connected with micro inverter became efficient in now-a-days. The proposed topology deals with the analysis of single phase grid connected PV system with the help of microinverter topology. The work describes the representation of micro inverter for neglecting the domino effect. This paper, differentiate the microinverter from the string inverter in order to increase the efficiency of the micro grid. The main aim of the grid tied PV micro inverter is to convert the raw solar energy from the PV panels and feed it to the grid with high efficiency and high power quality. This topology consists of the buffer and cycloconverter to increase efficiency. The main advantages of the proposed topology are: 1) Eliminating the double frequency effect, 2) There is no requirement of additional circuitry and 3) Using long lifetime capacitors. The proposed approach is analyzed and experimentally verified.

Index Terms: Microinverter, PV panel, Smart grid, Power quality

I. INTRODUCTION

The smart grid is incorporated with the digital and intelligence devices to replace the old analog devices in power network. In the traditional grid, there exists a string inverter, in which the inverters are connected in series. When one inverter gets affected, then the following inverter next to the fault inverter gets disconnected from the system. This is called as DOMINO EFFECT. To overcome this effect, this paper deals with the micro inverter, in which each inverter is placed behind the panel and are connected in parallel.

So that, the domino effect gets neglected. The PV Array is connected to the micro inverter. The PV panel must deliver the constant power. This can be done with the help of the maximum Power Point Tracking (MPPT) system which is placed in placed in between the PV panel and the micro inverter circuit. The cycloconverter is used to adjust the frequency of the alternate supply and it is fed into the micro grid.

II. SYSTEM ANALYSIS

2.1 Proposed Micro Inverter System

The proposed micro inverter is based on the conventional fly back inverter by adding an additional switch and diode in the primary side to realize the power decoupling function. In order to eliminate the double frequency effects at the PV side, the decoupling capacitor acts as an energy buffer. When the input power is greater than the output power the surplus power is being charged to the decoupling capacitor. In other case if the input power is less than the output power the deficit power is being supplied from the decoupling capacitor by turning on switch. Thus the operation is divided into two modes (i) charging mode and (ii) discharging mode.

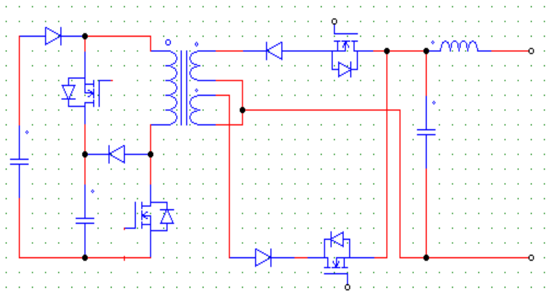

Fig. 2.1 Micro inverter with decoupling capacitor

2.2 DC-DC Converter

Here we use the type C chopper for converting a variable dc to fixed dc. An important advantage of this topology is a continuous current at both input and output of the converter. The dc chopper can also provide peak output voltages higher than the input voltages.

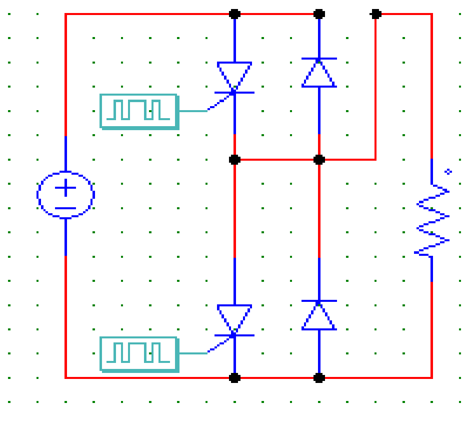

Fig. 2.2 Type-C DC – DC Converter

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2.3 MPPT implementation

There are large numbers of algorithm's to track MPPs. P&O method is the most frequently used algorithm to track the maximum power due to its simple structure and fewer required parameters. This method finds the maximum power point of PV modules by means of iteratively perturbing, observing and comparing the power generated by the PV modules. It is widely applied to the maximum power point tracker of the photovoltaic system for its features of simplicity and convenience. According to the structure of MPPT system the required parameters of the power-feedback type MPPT algorithms are only the voltage and current of PV modules. The relationship between the terminal voltage and output power generated by a PV module are shown below. It can be observed that regardless of the magnitude of sun irradiance and terminal voltage of PV modules, the maximum power point is obtained while the condition dP/dV = 0 is accomplished. The slope (dP/dV) of the power can be calculated by the consecutive output voltages and output currents, and can be expressed as follows,

$\left(\frac{dP}{dV}\right)n = (P(n) - P(n-1))/(V(n) - V(n-1))$ **- (2.3.1)**

Here, P (n) =V (n)*I (n) **- (2.3.2)**

In a fixed period of time, the load of the PV system is adjusted in order to change the terminal voltage and output power of the PV modules. The variations of the output voltage and power before and after changes are then observed and compared to be the reference for increasing or decreasing the load. If the perturbation in this time results in greater output power of PV modules than that before the variation, the output voltage of PV modules will be varied toward the same direction.

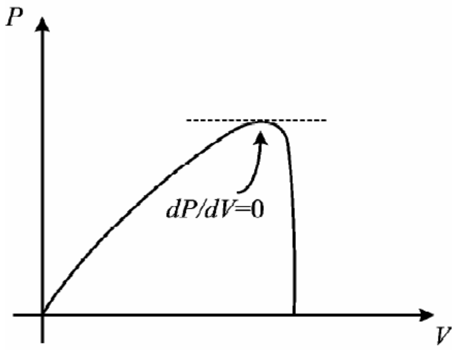

Fig. 2.3 Maximum power point prediction

Otherwise, if the output power of PV modules is less than that before variation, it indicates that the varying direction in the next step should be changed. The maximum output power point of a PV system can be obtained by using these iterative perturbation, observation and comparison steps. The advantages of the P&O method are simple structure, easy implementation and less required parameters. The shortcomings of the P&O method can be summarized as the power tracked by the P&O method will oscillate and perturb up and down near the maximum power point. The magnitude of oscillations is determined by the magnitude of variations of the output voltage. The Peak Power Tracker is basically a microprocessor controlled DC/DC converter. The MPPT is used in solar panel battery charging systems to increase the efficiency of the system by closing matching the input voltage of the solar panel to the output voltage of the battery.

2.4 Micro grid

This paper considers the simple micro grid system. The micro grid is formed in an island and different loads are also connected to micro grid system. The micro grid is defined as the independent lower medium voltage distribution network, comprises of various distributed generation units, energy storage units, power electronic interfaces, controllable loads and protective devices. Micro grid has an effective means of integrating distributed generation units into the power system.

2.5 Distributed generations:

Distributed generations are also called as on-site generation, which generates electricity from many small energy sources. In our system we use PV panel

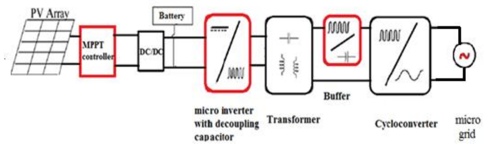

Fig. 2.4 Block Diagram of Proposed System

and wind turbine (optional) as a power source. It reduces the cost and complexity of the transmission and distribution.

III. TOPOLOGY OPERATION AND ANALYSIS

The solar PV panel would deliver the variable DC source and it is subjected to the MPPT controller. In MPPT Controller block, the maximum power is track by using the maximum power tracking algorithms. Then the dc component is passed through the chopper, which would convert the fixed dc to a variable dc. Then it is subjected to the micro inverter. In the micro inverter there are two modes of operation.

3.1 Operation in Mode-I

In this mode, the operation is divided into 4 circuit stages in each switching cycle. They are,

(i) Storing energy into the transformer's magnetizing inductance.
(ii) Charging the decoupling capacitor.
(iii) Transferring the power to the output.
(iv) Waiting for next switching circuit.

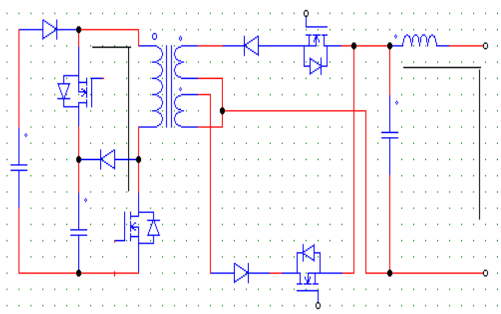

Fig. 3.1.1 Energy Stored in an Inductor

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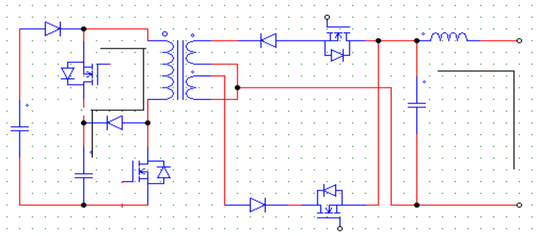

Fig. 3.1.2 Charging of Decoupling Capacitor

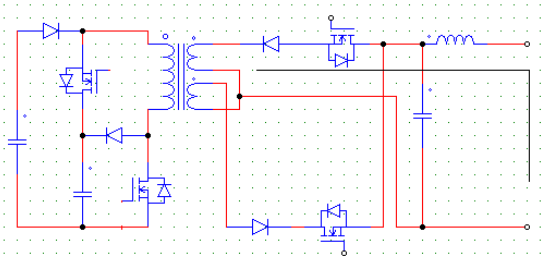

Fig 3.1.3 Transferring Power to Output

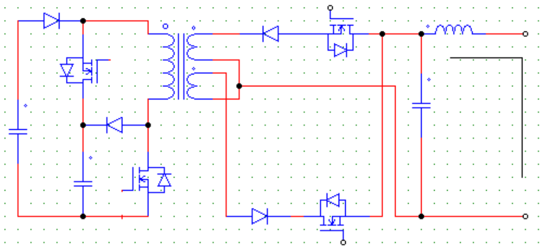

Fig 3.1.4 Waiting for Next Switching

3.2 Operation in Mode-II

Mode 2 is similar to mode 1, it also have four stages. Here the first and third stages are similar to be in the mode 1.Here the peak current has to be changed to maintain the input power constant and the decoupling capacitor would discharge the energy into transformer's ,magnetizing inductance. Now, the single phase supply from the micro inverter is subjected to the transformer to step up the voltage. After it is passed through the cycloconverter, here the phase can be changed. Then it is taken to the micro grid, there it is supply to the various loads.

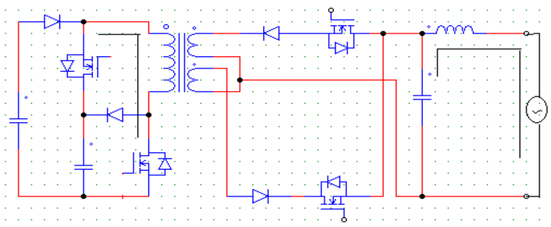

Fig 3.2.1 Charging of Magnetizing Inductance

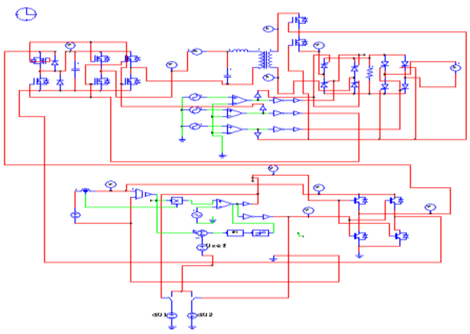

FIG 3.2.2 Circuit diagram using PSIM

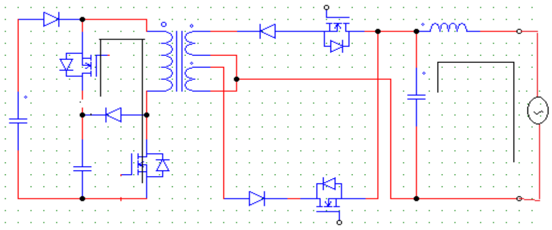

Fig. 3.2.3 Charging of Decoupling Capacitor

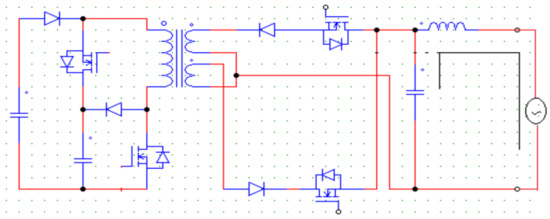

Fig. 3.2.4 Transferring Power to Output

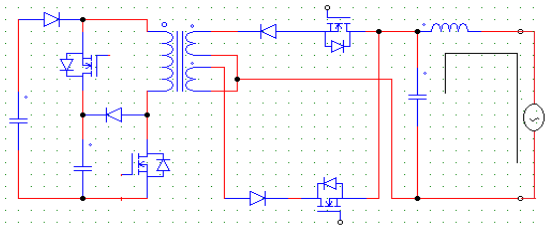

Fig. 3.2.5 Waiting for Next Switching

IV. EXPERIMENTAL RESULTS

To verify the proposed topology, simulation was done in PSIM software. The injected current into the grid is a pure sinusoidal, and the voltage ripple across the decoupling capacitor is 35 V peak to peak, which matches the calculation result. In mode I, when switch S1 turns OFF, the magnetizing energy is partially released to the decoupling capacitor through *D*1 and *D*2 .When the energy stored in the magnetizing inductor equals the energy that is needed to be injected into the grid, in one switching cycle, the switch S3 turns ON. Then the remaining magnetizing energy will be released into the secondary side, and finally, into the grid. In mode II, the magnetizing current still increase by turning ON switch S2. S2 does not switch OFF until the energy in the magnetizing inductor matches the energy required at the grid side in one switching cycle. The simulation results verify the proposed topology and its control strategy.

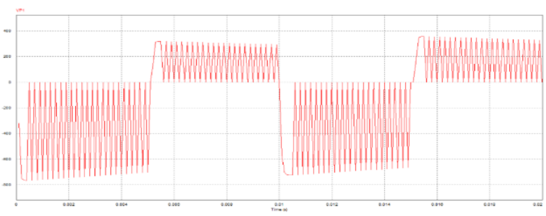

Fig. 4.1 Simulated Waveform of MPPT

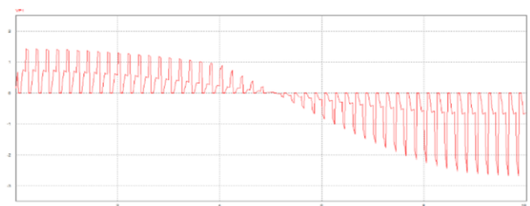

Fig. 4.2 Simulated Output Waveform

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V. CONCLUSION

New single phase PV grid connected micro inverter topology is presented. It is primarily intended for the ac–module PV systems. The proposed topology employs a new power decoupling technique where a small film capacitor can be used instead of the bulky, low reliable electrolytic capacitor. Hence, it will have a long lifespan comparable to the PV panel. It also consists of the micro inverter which would have more advantages than the string inverters, in which if one inverter gets damaged it will affect the whole system. But in micro inverter topology this would be neglected, because all the microinverter is connected in parallel, and it is placed back of the PV panel. The transformer leakage energy is handled by the decoupling circuit itself so there is no need for additional dissipative circuits, which leads to reduced power losses and improved efficiency. The wind and solar power are infinite and effective power utilization can be done.

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