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A Design and Implementation of Grid Connected PV System Using Interleaved Flyback Module Integrated Converter

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ABSTRACT:

Solar Energy has been utilized with the help of PV cell which contributes more for the future generation of power industry and can able to meet day to day challenges of increasing load. The PV Array can be connected in parallel and series combinations to increase its current and voltage capacity. An interleaved Flyback converter is connected to the PV array which helps in better utilization of DC link voltage, provides a distributed control and establishes a galvanic isolation between PV and Point of Common coupling .A small micro converter connected to PV array helps to give regulated DC supply as an input to the voltage source inverter connected to the grid. A point of Common coupling which lies after the DC converter increases the overall efficiency of the system. The output of the flyback converter is given as input to a voltage source inverter which is modulated by PWM signals. The output from the inverter is supplied to the grid and the proposed system is simulated using MATLAB/Simulink tool.

Keywords: PV array-Photovoltaic array, IFMIC-Interleaved Flyback module integrated converter.

Introduction:

Many literatures have been published based on PV generation. This paper also describes the Modeling of PV cell with MPPT technology which is connected to the grid through an interleaved flyback converter. Any distributed generation requires a power electronic converter which is used to convert DC to AC and vice versa depending upon the application. Since the efficiency of a solar cell is very less and the output obtained from it is not constant and the device is a nonlinear, effective harness of energy from the solar cell is very essential .In order to obtain maximum power from the solar cell always, MPPT algorithm is used. Many MPPT algorithm have been proposed in various literature out of those P& O MPPT algorithm is used which is easy and efficient algorithm to implement. The PV array output is connected to the grid through the interleaved flyback converter and an inverter. A flyback converter is normally used in switched mode power supplies which requires high voltages and less current. These converter are used in medium power applications. The flyback converter is preferred since it provides galvanic isolation between source and load. The isolation prevents both source and load from the effect of faults which may occur on either side. In this proposed Paper Section-I describes the basic structure and model of a PV cell with the MPPT algorithm . Section-II discuss about the principle of operation of a Flyback converter and section-III deals with simulation model of the proposed system with MATLAB/SIMULINK and discuss the output of the proposed system .

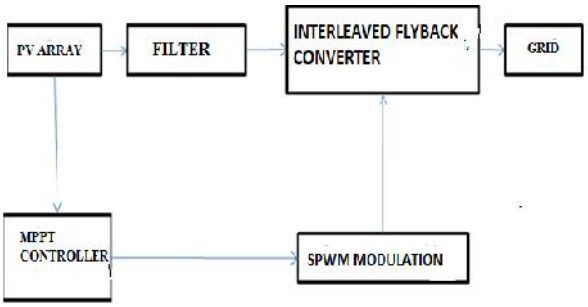

Fig.1 Block diagram of grid-tie PV power system with interleaved flyback converter.

I-PV Array

The individual PV power source is an array composed of identical PV panels in parallel and series. Each cell is fed by an independent PV panel. The power of the PV module varies depending on

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the insolation and load (operating point). So it is necessary to operate the PV at its maximum power point. Short-circuit current is directly proportional to the insolation. The solar cell operates in two regions, that is, constant voltage and constant current region. So it is essential to operate PV module at MPP always. MPPT is a two-step procedure. First step is to plot voltage vs power graph of the cell. Power is calculated by multiplying voltage across the cell with corresponding current through the cell. From the plot, maximum power point is located and corresponding voltage is noted. The second step is to plot the V-I characteristics of the cell and locate the current corresponding to the voltage at maximum power point. This current is called the current at maximum power point.

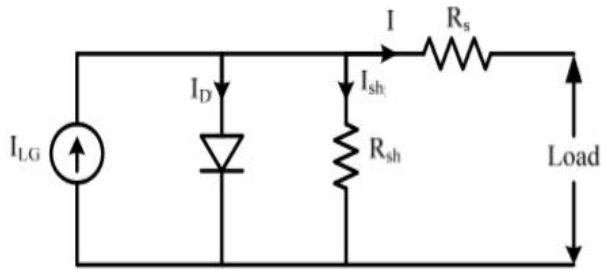

Fig 2: Model of a PV Cell.

DC-to-DC converter is used to balance between load and cell. The input resistance (Rin) depends on the load resistance and the duty cycle of converters. To the PV cell/module, the converter acts as a load and if Rin of the converter lies on the Vmp- Imp point, a system that automatically sets the duty cycle D value to duty cycle for MPP D mp such that maximum power can be transferred to the load. This is called Maximum Power Point Tracking or MPPT.Here Perturb & Observe (P&O) is used to obtain MPP from the PV array. The P & O algorithm states that when the operating voltage of the PV panel is perturbed by a small increment, if the resulting change in power ΔP is positive, then we are going in the direction of MPP and we keep on perturbing in the same direction. If ΔP is negative, we are going away from the direction of MPP and the sign of perturbation supplied has to be changed. Thus Maximum power can be exploited for the PV array connected to the IFMIC.

II. GRID CONNECTED IFMIC

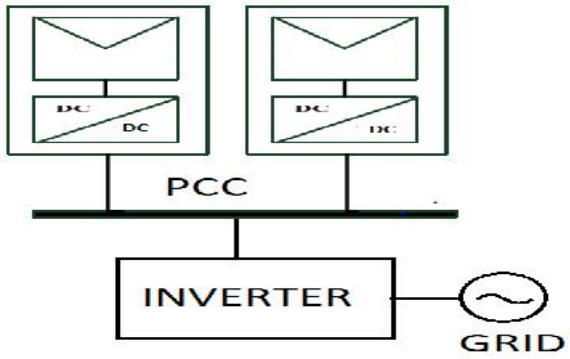

Fig:3 Micro Inverter based grid connected PV system.

Micro inverter topology is the development in the inverter configuration to overcome the losses and drawbacks of the centralized and string inverter system. As shown in Figure 3, the micro inverter topology consist of the module integrated inverter, means each module has its own low rated, small size inverter with separate MPPT for each module, so maximum power is supplied to the grid directly through this micro inverter. Grid connected micro inverter system consist of single PV panel, DC-DC converter for boosting the PV voltage with MPPT, Full bridge inverter (unfolding bridge), EMI filter and grid connection. Main advantage of micro inverter system is to reduce or eliminate the shading and clouding effect in the PV systems. In this topology, if partial shading occurs on one module, it will affects the performance of only that module and performance of the other modules will not be get affected.[2,3]

It also gives more accuracy in MPP operation, because each module has its separate MPPT, removing mismatch losses between PV modules. Hence, the energy harvesting to grid increases as compared to the central and string inverter system because of increasing efficiency of the system. Micro inverter topology eliminates the use of DC cables and requirement of the electrolytic capacitor, due to which, the maintenance becomes less and lifespan of the inverter increases. Design of the micro inverter is flexible and compact. It is like 'Plug-n-Play' device, which can be installed and operate easily even by a person, without any knowledge or expertise in the electrical or PV

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installation. So, the micro inverter configuration gained popularity due to above advantages.[5]

There are various converter topologies used for the design of micro inverter like simple fly back converter, push pull converter, forward converter and interleaved fly back converter. Mostly, fly back converter is preferred for single phase grid connected micro inverter, because, it is efficient for small power rating, and in micro inverter, only single module is connected, so power rating is low, also it has less components, single stage conversion and galvanic isolation between PV module and grid line.

Forward converter is also step up DC voltage of PV panel and provides galvanic isolation, but when comparing these two converters, the fly back converter requires fewer components than that of the forward converter, as there is no need of output inductor and freewheeling diode at output side, so, fly back topology is selected. Fly back converter is generally used for small low power rating application, so, for increasing a power rating to improve performance of fly back converter, the interleaved structure is used, in which two fly back converters are interleaved to each other. Also, by using interleaved technique, the conduction loss of each switch is reduced and reliability is increases. [6]

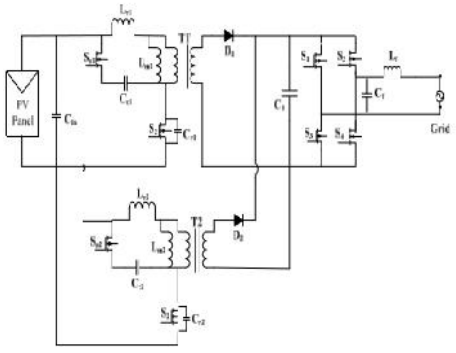

Fig 4 shows the circuit configuration of micro inverter, based IFMIC

The IFMIC consists of decoupling capacitor, first phase fly back converter and second phase fly back converter, which are interleaved to each other, unfolding bridge (full bridge inverter) and EMI filter. IFMIC extract DC power from PV panel and harvest AC power to the grid.

Each phase of fly back converter consist of main switches, transformer, diode and active clamp circuit as shown in Figure 4. A clamp circuit is used to decrease the voltage spike across switch. Fly back transformer is used to boost voltage from PV panel and maintain isolation between the PV module and grid line. Unfolding bridge is used to convert rectified AC from interleaved fly back converter to sinusoidal AC, which is compatible to grid. EMI filters are used to remove unwanted harmonics and supply pure AC voltage to grid.[7,8]

The operation of active clamped interleaved fly back converter is depending upon the switching of main switches and auxiliary switches. Gate signals given to the main switches Q1 and Q2 are 180^0 out of phase, and gate signals to auxiliary active clamped switches Sa1 and Sa2 are applied to short time, after corresponding main switches are off for reducing voltage spike and conduction losses.

III Simulation Results:

The simulation of the proposed system is done using MATLAB/Simulink. The PV array is the combination of solar cells connected in series and parallel combination which provides supply of 50V DC supply. Flyback converters which are connected in parallel which supplies constant supply for the inverter with 180^o phase displacement. The Voltage source inverter is used to produce a sinusoidal output of 230V is connected to the Grid. The Figures show the output of the PV, voltage across the capacitor, current across the inductor and the voltage and current waveforms connected to the grid.

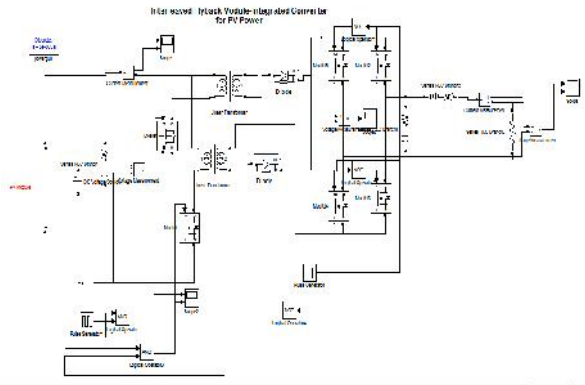

Fig 5 IFMIC based grid connected PV systems

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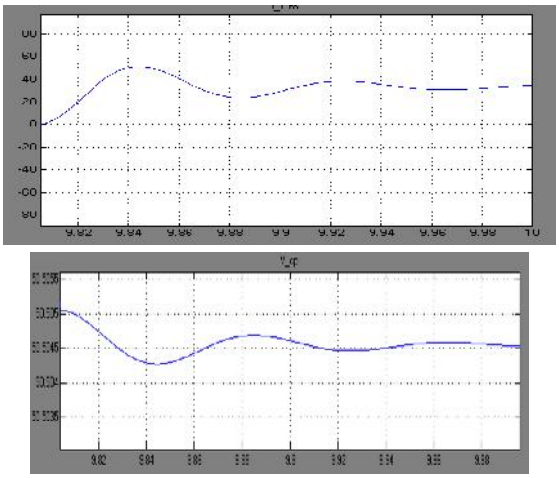

Fig: 6 Current flowing through Inductor

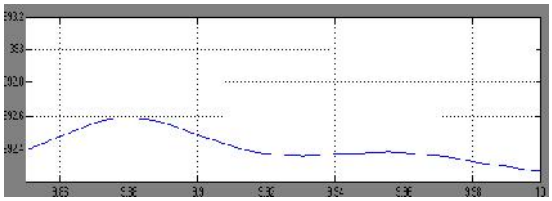

Fig7: Voltage across the capacitor

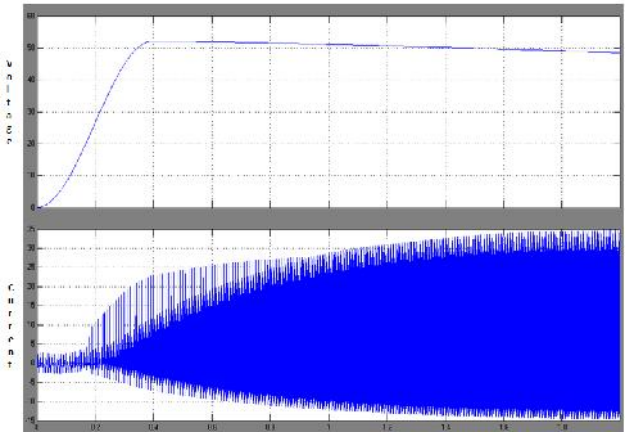

Fig 8: Voltage and current of PV array

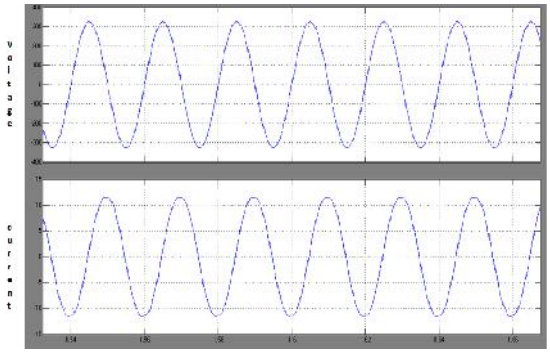

Fig:9 Voltage & Current of the grid

IV Conclusion:

Solar Energy is utilized with the help of PV cell which helps the future power industry to meet the demand.. The interleaved Flyback converters are connected to the PV array helps in better utilization of DC link voltage and provides a distributed control to PV Panel. A small micro converter connected to PV array helps to give regulated DC supply as an input to the voltage source inverter connected to the grid. A point of Common coupling which lies after the micro converter increases the overall efficiency of the system. The output of the flyback converter is given as input to a voltage source inverter which is modulated by PWM signals. The output from the inverter is supplied to the grid .

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