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DESIGN OF HERIC INVERTER FOR PHOTOVOLTAIC SYSTEM

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Abstract--- Introduction:*. The Highly Efficient and Reliable Inverter Concept (HERIC) [6] inverter is a cost-effective topology, which has low leakage currents [4] and a relatively high efficiency. Thus, it is very suitable for transformer less PV systems with boost converters. Due to reduced number of switches, switching losses may be reduced. However, with the modulation methods, it is difficult to simultaneously maintain the high efficiency, reduced switching losses, good power quality, and reactive power [10] injection of the HERIC inverter. In this project, a hybrid sine pulse width modulation (H-SPWM) scheme is thus proposed to achieve those performances. The hybrid scheme adopts the conventional SPWM [7] in the case of generating the positive power. When generating the negative power, a modulation scheme, which only requires the operation of freewheeling switches, is specifically proposed. The results demonstrate that the proposed hybrid SPWM method achieves a better performance in terms of reactive power injection than the conventional UP-PWM scheme [9], and a higher efficiency than the PWM with dead time. In addition, the proposed H-SPWM [12] scheme also enables a better power quality and achieves better performance and improves the THD than existing methods.*

Keywords---*: HERIC, Inverter, Boost Converter, Transformer-less PV, PWM, SPW*

I. INTRODUCTION

Renewable energy sources are the attractive source of energy because of increased fuel utilization, exhausting fossil fuels and their effect on environment issues. Solar energy, depletion of ozone layer etc. In order to conquer the negative effect of fossil fuels is one of the most attractive sources of renewable energy. Subsequently the photovoltaic inverters are turning to an interesting topic for researchers. These inverters converts the direct current (DC) supplied by the solar panels into alternating current (AC) and feeds it into the utility grid.

Hence the line transformers are being used in order to provide electrical insulation between the grid and the solar panel and also to conquer the leakage current. But due to the plenty of disadvantages such as weight, size, cost, and efficiency it finds a low application now days. High frequency dc-dc transformers are also being used so as to provide galvanic isolation but the efficiency of photovoltaic grid [1] connected system is still

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unsatisfactory. Thus to improve the efficiency, transformer less grid connected photovoltaic inverters with low leakage current [8] finds a wide application.

In this paper HERIC (Fig. 1) configuration based transformer less single-phase PV topology [3] is being analyzed using MATLAB. The main idea is to increase the productivity and diminish the leakage current. A prototype of single phase grid connected PV system is developing to verify the results [13-15].

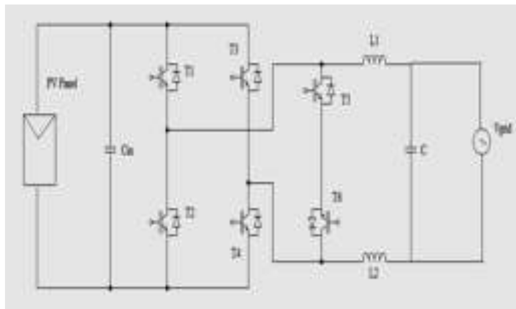

Fig. 1High Efficient and Reliable Inverter Concept (HERIC)

Transformer less photovoltaic (PV) grid-connected inverters [2] have the advantages of higher efficiency, lower cost, less complexity, and smaller volume compared to their counterparts with transformer galvanic isolation.

II. PROPOSED MODULE

PHOTO VOLTAIC GROUPING

Photo Voltaic Cell

PV cell are basically semiconductor diode. This semiconductor diode has got a p-n junction which is exposed to light. When illuminated by sunlight it generates electric power. PV cell are made up of various semiconductor materials. But mono-crystalline silicon and poly-crystalline silicon are mainly used.

Photo Voltaic Module

The power produced by a single PV cell is not enough for general use. So by connecting many single PV cell in series (for high voltage requirement) and in parallel (for high current requirement) can get us the desired power. Generally a series connection is chosen this set of arrangement is known as a module. Generally commercial modules consist of 36 or 72 cells. The modules consist of transparent front side, encapsulated PV cell and back side. The front side material is usually made up of low-iron and tempered glass. The efficiency of a PV module is less than a PV cell. This is due to the fact that some radiation is reflected by the glass cover and frame shadowing etc.

Photo Voltaic Array Modeling

A photovoltaic array (PV system) is a interconnection of modules which in turn is made up of many PV cells in series or parallel. The power produced by a single module is seldom enough for commercial use, so modules

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are connected to form array to supply the load. The connection of the modules in an array is same as that of cells in a module. Modules can also be connected in series to get an increased voltage or in parallel to get an increased current. In urban uses, generally the arrays are mounted on a rooftop. In agricultural use, the output of an array can directly feed a DC motor. The photo voltaic array is developed by the basic equations of photovoltaic cells including the property of temperature change and photo voltaic irradiation intensity. The output voltage of the photo voltaic cell is a purpose of photo current that is mostly determined by load current depending on the solar irradiation level. The photo voltaic cell output voltage is expressed as

$$V_C=AKTc/e \text{ in } (I_{ph}+I_o -I_C)-Rs\ I_C$$

$$V_{pv}=V_C\times N_s$$

$$I_C=I_{pv}/N_p$$

$$CTv=1+\beta T\ Ta-Ty$$

$$CT_I=1+\gamma T/S_r\ T_y-T_a$$

Where bT = 0.004 and cT = 0.006. These two parameters are used to scale the effects of high temperature and solar irradiation levels on photo voltaic cell voltage and current. bT is the slope of the coefficient CTV, affect the change in voltage due to temperature change time is a constant in a place of change in working temperature due to solar irradiation. Ta and Ty represent the ambient temperature of the cell respectively

The change in the photocurrent and working temperature due to change in the solar irradiation level can be expressed as follows:

$$CSV=1+\beta T\ \alpha s\ (SX-SR)$$

$$CSI=1+1/Sc\ (SX-SR)$$

Where Sc is the benchmark reference solar irradiation level during cell testing. Sr is the reference solar irradiation level (1000 W/m3), Sx is the new level of solar irradiation and as is the slope of the change in the solar irradiation level.

III. PROPOSED CONVERTER

The Highly Efficient and Reliable Inverter Concept (HERIC) inverter (Fig. 2) is a cost-effective topology, which has low leakage currents and a relatively have better efficiency. Thus, it is very suitable for transformer less PV systems. However, with the reported modulation methods, it is difficult to simultaneously maintain the high efficiency, good power quality, and reactive power injection of the HERIC inverter.

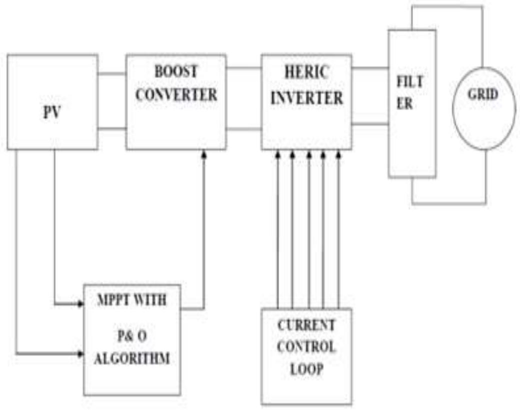

Fig. 2 Proposed Block Diagram

In this paper, a hybrid unipolar pulse width modulation (UP-PWM) scheme is thus proposed to achieve those performances. The hybrid scheme adopts the conventional UP-PWM in the case of generating the positive power. When generating the negative power, a modulation scheme, which only requires the operation of freewheeling switches, is specifically proposed. Additionally, in the region of the output voltage and current zero-crossing points (ZCP), an UP-PWM with modified dead time is introduced.

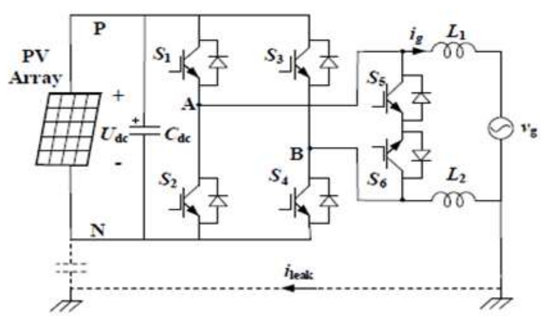

Fig. 3 Existing Converter Scheme

In order to validate the effectiveness of the this scheme, simulations results of this hybrid UP-PWM method achieves a better performance in terms of reactive power injection than the conventional UP-PWM scheme, and a better efficiency than the UP-PWM with dead time. In addition, the existing UP-PWM scheme also enables a better power quality. To increase the power quality, efficiency, THD, inverter injection current to the grid better than the existing system we proposed a new single phase single stage transformer less PV-HERIC inverter system using SPWM method (Fig. 3).

A single phase transformer less grid connected inverter with six power switches (S1, S2, S3, S4, S5, and S6) is being analyzed. The operation mode of the topology is analyzed through simulation. In this project, a two stage topology without galvanic isolation is been carried out for a grid connected single phase photovoltaic inverter. The output from the solar panel is fed to DC/DC boost converter in order to obtain constant boosted voltage, maximum power point tracking (MPPT) [11] control technique is being used to control the gate pulse of the MOSFET [5] of boost converter. These constant boosted outputs are fed to the highly efficient and reliable inverter concept (HERIC) inverter in order to convert DC into AC with higher efficiency. Proposed system eliminates the two diodes across the S5 & S6 switches, so it will reduce the losses and improves the system performance.

The main aim of the proposed system is to inject the circulating current to the grid continuously at maximum power rating. For this purpose we introduced two mosfet switches(S5,S6),during S1,S2,S3,S4-OFF,S5 & S6 will be ON and circulate the inverter current to the grid smoothly with highly effective and reliable manner. Results of the proposed system is shown in chapter 6.From the generated results we say that proposed system will works higher efficiency than the existing system. At the same we reduce the reactive power injection so, we achieve good THD than the existing system.

IV. OUTPUT AND RESULTS

SIMULATION DIAGRAM OF PROPOSED METHOD

The simulation of complete PV system is being carried out without MPPT using MATLAB/Simulink (Fig. 4 & 5). The simulation model includes PV panel followed by DC-DC boost converter, HERIC inverter and current control loop.

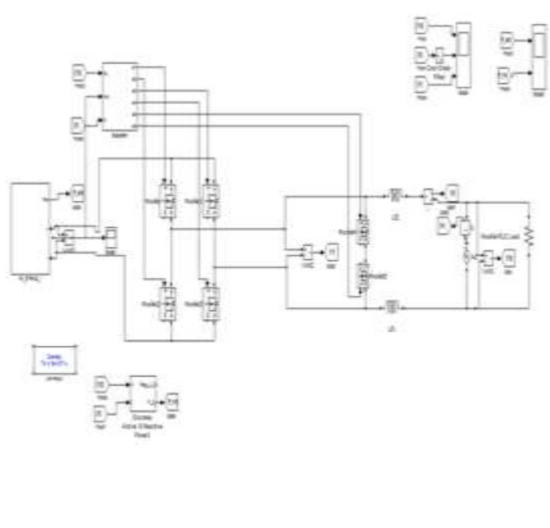

Fig. 4 Simulation Diagram of PV with HERIC Inverter module

In a grid connected photovoltaic system, the main aim is to design an efficient solar inverter with higher efficiency and low THD and which also controls the power that the inverter injects into the grid. The effectiveness of the general PV system anticipates on the productivity by which the direct current of the solar module is changed over into alternating current. The fundamental requirement to interface the solar module to the grid with increased productivity includes: Low THD of current injected to the grid, maximum power point (Fig. 6).

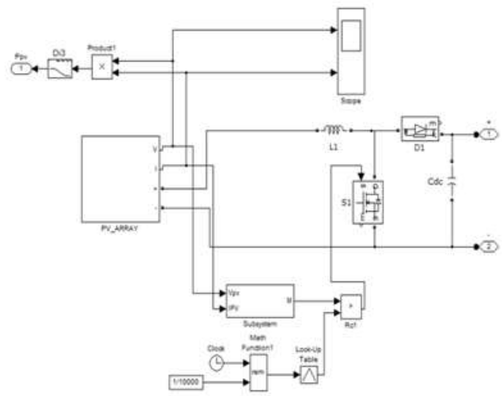

Fig. 5 Simulation Diagram of PV Unit with Boost Converter

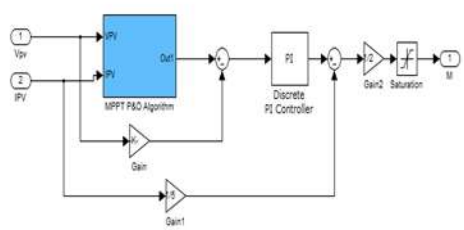

Fig. 6 Simulation Diagram of MPPT with P & O Algorithm

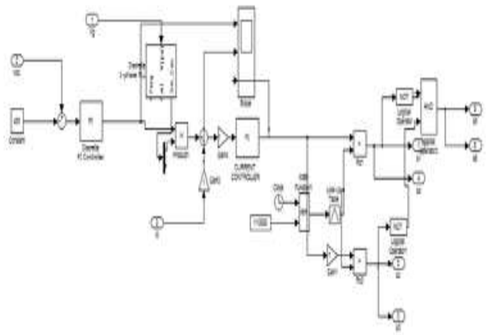

Fig. 7 Simulation Diagram of Current Control Loop

The main strategy used to control the grid tied PV power converters is the current mode control (Fig. 7). This technique consists in calculating an adequate current reference to inject active power into the grid. Then, a current control loop is designed based in the model of the system. Additionally, a Phase Locked Loop (PLL) can be used to synchronize the injected current with the grid voltage.

A single phase transformer less grid connected inverter with six power switches is being analyzed. The operation mode of the topology is analyzed through simulation and its results are given below. The results given below shows that our proposed system works in excellent way and improves the system efficiency and reduce the total harmonic distortion within the prescribed value set by IEEE standard (Fig. 7,8, 9 & 10).

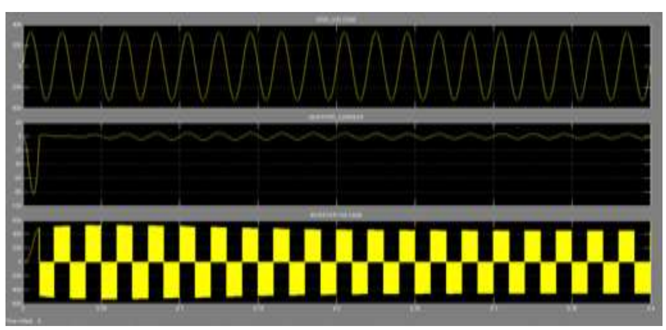

Fig. 8 Simulation Output of Grid Voltage/Inverter Current/Inverter Voltage

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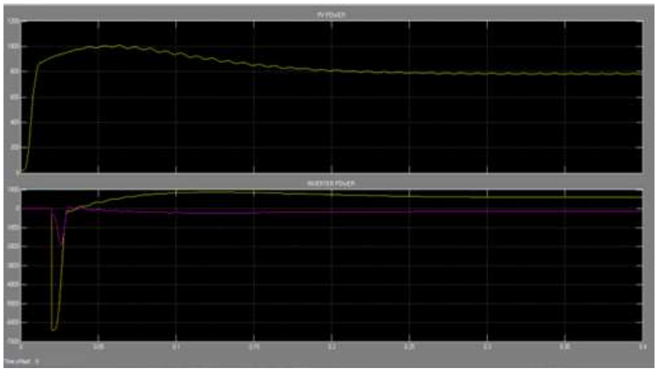

Fig. 9 Simulation Output of PV Power/Inverter Power

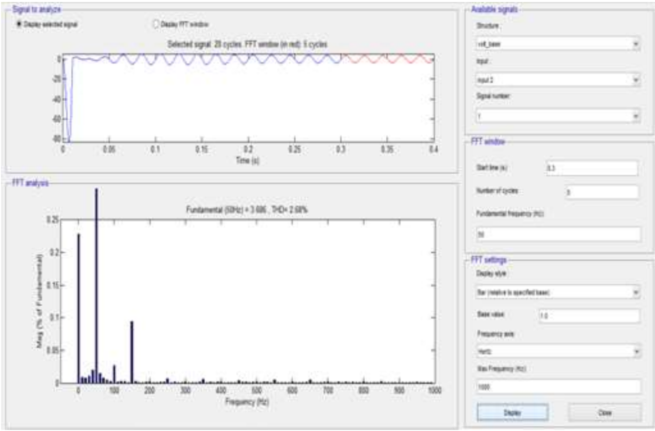

Fig. 10 Simulation Output of Proposed SPSS PV-HERIC INVERTER THD Value (2.68%)

V. CONCULSION

A high reliability and efficiency inverter for transformer less PV grid-connected power generation systems is presented in this paper. The main characteristics of the proposed transformer less HERIC inverter are summarized as follows:

- Ultra high efficiency can be achieved over a wide output power range by reliably employing super junction MOSFETS for all switches since their body diodes are never activated;
- Low distortion so improves the total harmonic distortion.
- No shoot-through issue leads to greatly enhanced reliability;
- Low ac output current distortion is achieved because dead time is not needed at PWM switching commutation instants and grid-cycle zero-crossing instants;Low-ground loop CM leakage current

is present as a result of two additional unidirectional-current switches decoupling the PV array from the grid during the zero stages;

- Higher switching frequency operation is allowed to reduce the output current ripple and the size of passive components while the inverter still maintains high efficiency;
- The higher operating frequencies with high efficiency enables reduced cooling requirements and results in system cost savings by shrinking passive components.
- With the high efficiency and better THD, high quality of inverter output current and greatly enhanced reliability, the proposed topology is very attractive for transformer less PV- inverter applications.

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