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Study of H6 Transformerless Full Bridge PV-Grid Tied Inverters

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***Abstract*—Inverters with transformers of conventional type, connected in PV grid-tied generation systems have now being replaced by transformer less inverters due to various reasons such as reduction in size, weight and cost, improvement in efficiency etc. Transformer less inverters causes a number of technical challenges in grid-connected PV systems, among which flow of leakage currents is a major problem. This leakage currents that flows between the parasitic capacitance of PV array and the grid has to be eliminated, which otherwise leads to serious safety problems. This paper deals with an H6 transformer less full- bridge inverter topology with low leakage currents that can be used in PV grid – tied applications. A closed loop has been developed for maintaining the voltage constant at the grid side. Aforementioned transformer less topology is simulated that validates the effectiveness of the inverter.**

***Index Terms*— Common-mode voltage; grid-connected inverter; leakage current; photovoltaic (PV); transformerless inverter component; formatting; style; styling; insert (key words).**

I. INTRODUCTION

Nowadays, the invention and development of new energy sources are increasing due to the poisonous results caused by oil, gas and nuclear fuels. This has led the renewable energy sources especially the solar PV systems to the prime position
in the generation of electricity[4] . Photovoltaic have applications ranging from small power supplies to power grids. Photovoltaic systems connected to the grid have several advantages such as simplicity in installation, high efficiency, reliability and flexibility [5]. With a reduction in system cost PV technology seems to be an efficient means of power generation. A solar grid connected power generating system usually consists of a solar panel in which the solar cells are arranged to track sunlight, an inverter to convert the DC to AC and the grid. This paper evaluates a single phase transformer less inverter topology called H6, which can minimize the dangerous leakage currents between the solar power generation system and the electrical grid. Transformers are employed in the grid tied systems to provide a galvanic isolation between the PV panel and the grid for safety considerations [2]. Line frequency transformers were employed in most of the PV grid tied inverters. But in line frequency transformers due to their low frequency, the size, cost, weight etc. will be higher. The next option is the high frequency transformers. The usage of high frequency transformers increases the number of power stages which affects the efficiency in an adverse manner [1].

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When these transformers are eliminated there will be a galvanic connection between the solar module and the grid which results in a potential fluctuation between the PV array and the ground. The potential variation leads to the flow of common mode leakage currents that has to be eliminated which otherwise leads to electromagnetic distortions, interferences, harmonics and other power quality issues. The H6 transformer less inverter topology with unipolar sinusoidal PWM strategy seems to be a better solution to reduce these leakage currents by maintaining the common mode voltage constant. A simple boost converter is employed to boost the voltage available from the PV panel so as to connect to the grid.

The paper is organized as follows: Transformer less H6 inverter circuit configuration and principle of operation is presented in Section II. Simulation result of H6 transformer less inverter is given in section III .Finally conclusion is stated in section IV.

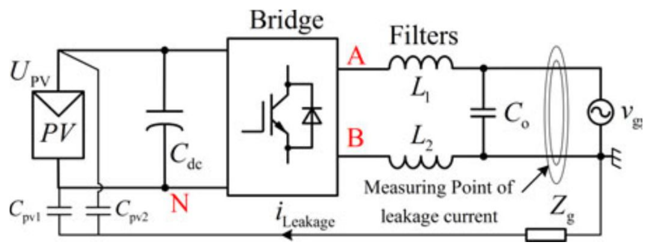

Fig.1 Leakage Current path for transformer less PV inverter

II. CIRCUIT CONFIGURATION AND PRINCIPLE

Fig 2 shows the circuit diagram of the proposed H6 inverter topology. It consists of six MOSFET switches S_1, S_2, S_3, S_4, S_5 and S_6. The modulation technique used is the unipolar sinusoidal PWM. The photovoltaic panel is represented by Vpv. An LCL filter is used for filtering purpose. V_g represents the electrical grid. Cdc represents the input dc capacitance.

Mode 1, Active Mode: During active mode of positive half period switches S_1, S_4 and S_5 will conduct and switches S_3 and S_6 remains in the off position. The direction of current flow is indicated by the arrows. The common mode voltage VCM is given by, V_{CM} = (Van + Vbn)/2 ≈ 0.5VPV.

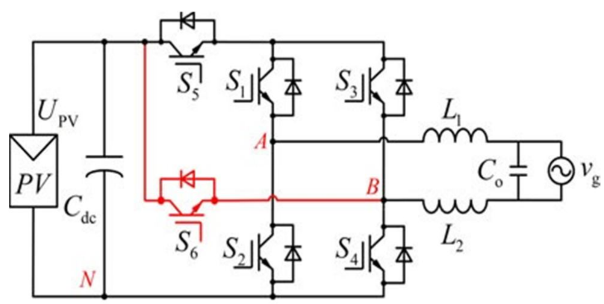

Fig 2 H6 type inverter topology

Mode 2, Freewheeling Mode: During freewheeling mode of positive half period, current freewheels through switch S_1 and the antiparallel diode S_3.All the other switches remains in off position. The common mode voltage during this period is given by V_{CM}=Van +Vbn/2=0.5VPV.

Mode 3, Active Mode: During active mode of negative half period switches S_2, S_3 and S_6 will conduct and switches S_1 and S_4 remains in the off position. In this mode of operation although three switches are turned on, current flows through only S_2 and S_6 and hence the conduction losses can be reduced. The direction of current flow is indicated by the arrows. The common mode voltage V_{CM} is given by V_{CM} = (Van + Vbn)/2 ≈ 0.5VPV.

Mode 4, Freewheeling Mode: During freewheeling mode of negative half period, current freewheels through switch S_3 and the antiparallel diode S_1.All the other switches remains in off position. *S*3is turned ON, and the other switches are turned OFF. The inductor current is flowing through *S*3 and the antiparallel diode of *S*1 .$v_{AN} = v_{BN} \approx 0.5U_{PV}$; thus, $v_{AB} = 0$, and the CM voltage $v_{CM} = (v_{AN} + v_{BN})/2 \approx 0.5U_{PV}$.

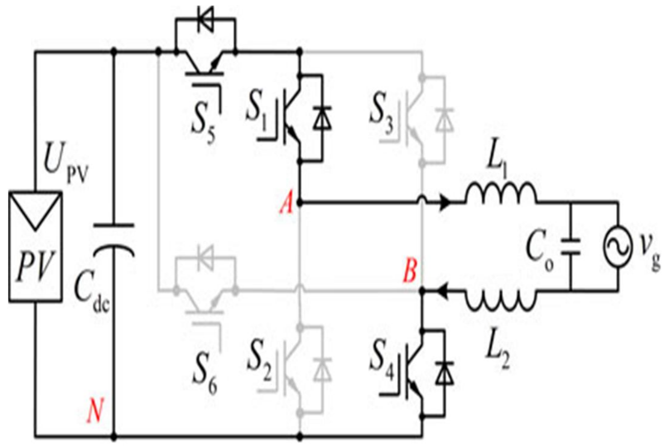

Fig 3 Active Mode in the Positive half period

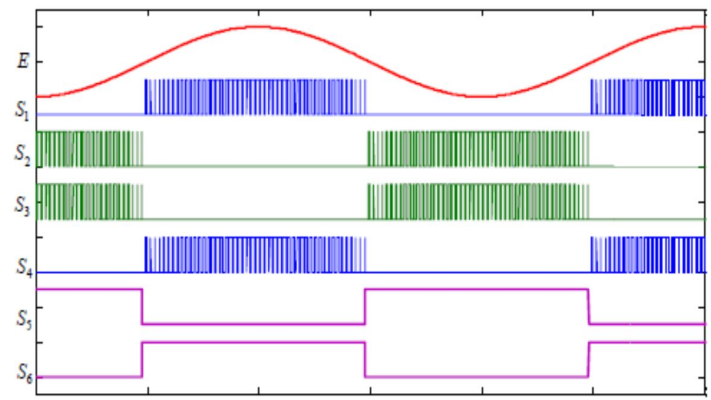

Fig 4 Moduation scheme for gate drive signals

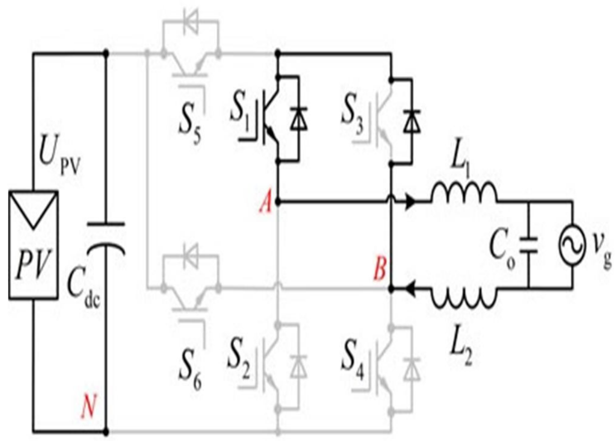

Fig 5 Freewheeling Mode in the positive half period

The full-bridge inverter only needed half of the input voltage demanded value by the half-bridge topology, and the filter inductors L_1 and L_2 are usually with the same value.

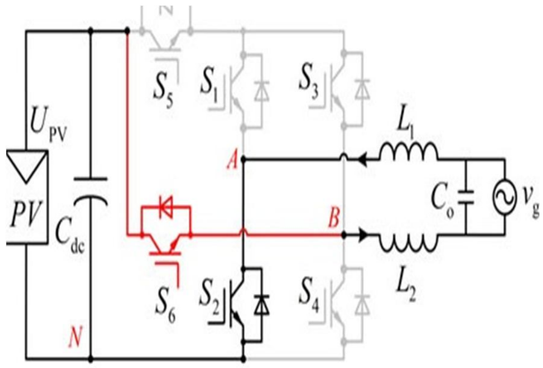

Fig 6 Active Mode in the negative half period

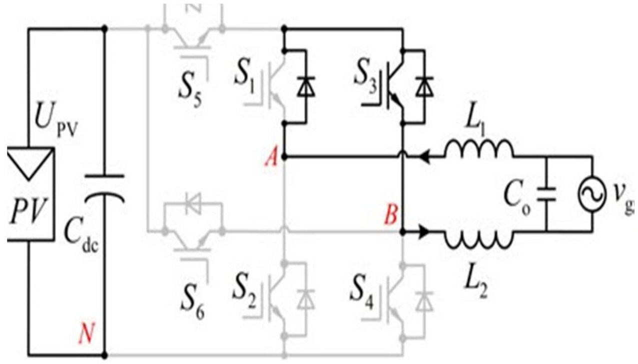

Fig 7 Freewheeling mode in the negative half period

III. SIMULATION RESULTS

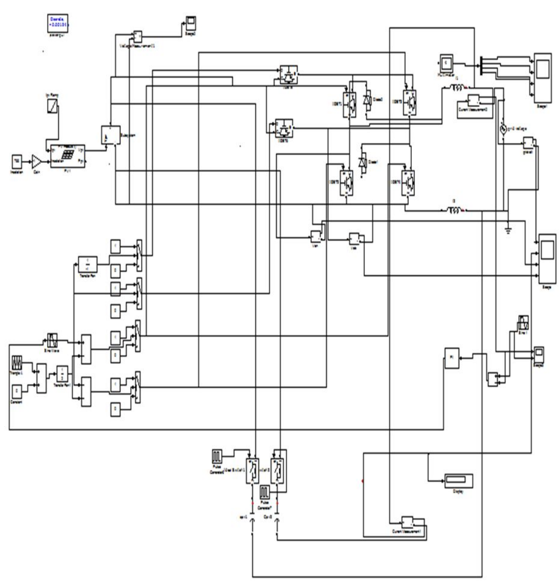

Fig 8simulation model of H6 transformer less inverter

TABLE I.

PARAMETERS	VALUES
Rate power	1000W
Filter capacitor	0.47µF
Filter Inductance L_1,L_2	106µH
Input voltage	400V
Grid voltage/frequency	230V/50Hz
Input capacitance C_{dc}	940µF
Switching frequency	20kHz

Simulation for the H6 transformer less full bridge inverter is done in mat lab. Input voltage =400V, Grid voltage-230V,switching frequency fs =20KHz, inductor values L1=3mH, L2 =3mH. The leakage current waveform of the H6 topologies is obtained with minimum leakage current. vAN and vBN are the voltages between the midpoints A and B to terminal N, respectively. v_{CM} is the CM voltage, which equals to $0.5(v_{AN} + v_{BN})$.

The voltage potential of the positive terminal of the PV array is equal to that of the terminal (B), in the negative half period of the utility grid voltage, so the drain–source voltage of switch S_5 is zero. Thus, the switch S5 only has switching loss in the positive half period of the utility grid, and the switch S_6 only has switching loss in the negative half period of the utility grid. The main power losses of switches in each operation mode include the turn-ON/OFF loss, conduction loss, diode freewheeling loss, diode reverse recovery loss, and gate loss.

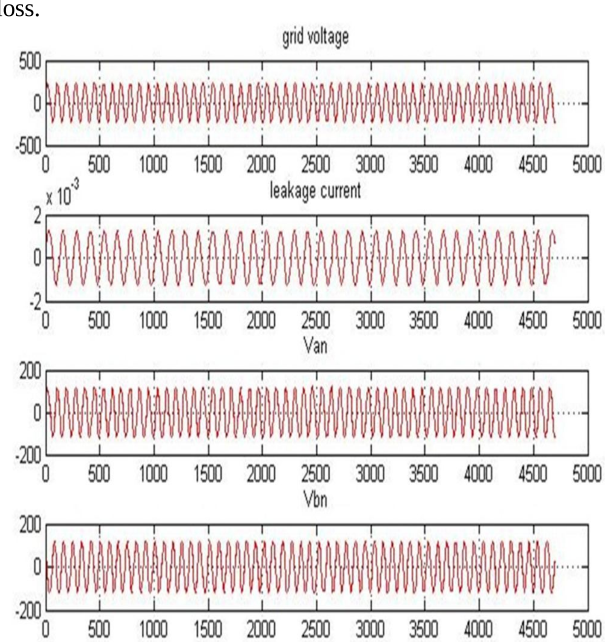

Fig 9 simulation result

IV. CONCLUSION

The solar power is fed to the grid through an inverter. There are different topologies of inverter with and without galvanic isolation. In this work a topology, H6 topology is taken for analysis, design and simulation. An H6 topology is designed for 230 volts, 50 Hz. The circuit is simulated to verify the design and to check whether the reference grid current is obtained. The leakage current is also tested through simulation. Now it is found that the design objectives are satisfied through simulations. The switching voltages of all commutating switches are half of the input dc voltage AND the switching losses are reduced greatly. Finally, theoretical analysis and performance evaluation results indicate that the H6 topology can effectively reduce the leakage current to an acceptable level. The conversion efficiency of H6 is better than any other transformer less topologies. The thermal stress is also better than any other topologies. It also achieved the excellent DM performance like the isolated full-bridge inverter with unipolar SPWM. Therefore, the proposed H6 topologies are good solutions for the single phase transformer less PV grid-tied inverters.

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