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RESEARCH ARTICLE

A NOVEL PWM METHOD OF IMPROVING EFFICIENCY OF SINGLE PHASE TRANSFORMERLESS PHOTOVOLTAIC INVERTER

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ABSTRACT

This paper presents the novel method that is used to improve the efficiency of a single phase transformerless photovoltaic inverter connected to the grid along with the elimination of ground leakage current, the result was simulated through computer software tool using MATLAB/SIMULINK VERSION 7.9. In the conventional method of grid connected system there is an drawback of lower isolation efficiency and presence of ground leakage current. This problem can be overcome by isolating both the grid and source individually using switching arrangements along with HERIC circuit. This topology improves the efficiency of the system and provides better isolation and minimizes the losses in the Single phase transformerless photovoltaic inverter connected to the grid [1].

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INTRODUCTION

Grid-connected Photovoltaic (PV) systems, particularly single-phase systems, are becoming more important worldwide. Quite often, these grid-connected PV systems include a line transformer in the power-conversion stage, which guarantees galvanic isolation between the grid and the PV system, thus providing personal protection. Furthermore, it strongly reduces the leakage currents between the PV system and the ground, ensures that no continuous current is injected into the grid, and can be used to increase the inverter output voltage level [2]. The line transformer is large, heavy and expensive. Technological evolution has made possible the implementation, within the inverters, of both ground-fault detection systems and solutions to avoid injecting dc current into the grid. The transformer can then be eliminated without impacting system characteristics related to personal safety and grid integration. The advantages of eliminating transformer are reduction on manufacturing and maintenance cost, Size of the unit was much reduced and efficiency of the whole system improves[5].

II COMMON-MODE CURRENTS IN TRANSFORMERLESS PV SYSTEMS

When no transformer is used, a galvanic connection between the ground of the grid and the PV array exists. As a consequence, a common-mode resonant circuit appears, consisting of the stray capacity between the PV modules and the ground, the dc and ac filter elements, and the grid impedance. A varying common-mode voltage can excite this resonant circuit and generate a common-mode current.

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Due to the large surface of the PV generator, its stray capacity with respect to the ground reaches values that can be even higher than 200 nF/kWp in damp environments or on rainy days. These high values can generate ground currents with amplitudes well above the permissible levels, such as those concerning the standards. The currents can cause severe (conducted and radiated) electromagnetic interferences, distortion in the grid current and additional losses in the system [3].

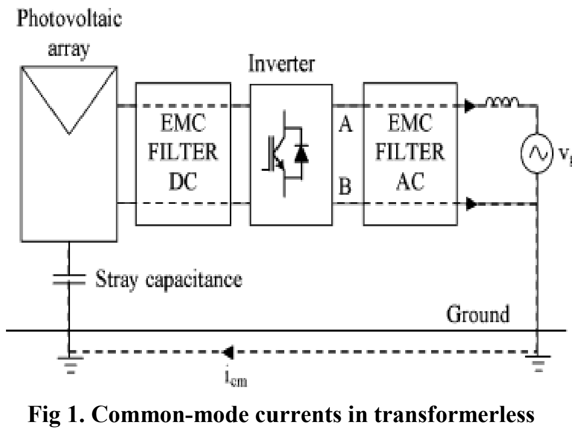

Fig 1. Common-mode currents in transformerless pv systems

These leakage currents can be avoided, or at least limited, by including damping passive components in the resonant circuit [3]. Obviously, additional losses will appear in the damping elements, thus decreasing the conversion stage efficiency. To avoid leakage currents, the common-mode voltage must be kept constant during all commutation states.

III PROPOSED TOPOLOGY

CIRCUIT DIAGRAM OF PROPOSED METHOD:

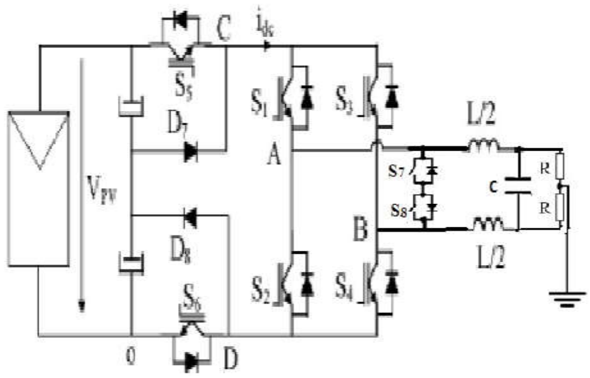

Fig 2. Circuit diagram of proposed model

The proposed topology, which consists of Eight switches (S1-S8) and two diodes (D7 –D8). In this topology, D7, D8 diodes and the capacitive divisor limit the blocking voltage of S5 and S6 to half of the input voltage VPV. S7 and S8 functions as a HERIC Grid-connected PV systems usually operate with unity power factor. The operational principle of the proposed converter is now analyzed for this case. The proposed topology with the modulation technique described below can operate with power factors other than unity. In these cases, the operation analysis would be similar. In the positive half cycle, S1 and S4 are on. In order to modulate the input voltage, S5 and S6 commutate at the switching frequency with the same commutation orders S2 and S3 commute at the switching frequency together and complementarily to S5 and S6. In this situation, when S5 and S6are on,VAB = VPV and the inductor current, which flows through S5 ,S1 ,S4 , and S6, increases. The common-mode voltage is:

$$v_{cm} = (v_{AO} + v_{BO})/2 = (V_{PV} + 0)/2 = V_{PV}/2.$$

When S5and S6 are turned off and S2 and S3 are turned on, the current splits into two paths: S1 and the freewheeling diode of ,S3 and S4 and the freewheeling diode of S2 . Thus,S2 and S3 are turned on with no current and therefore no switching losses appear. In this situation, voltages VA0 and VB0 tend to zero and diodes and fix the voltages and to VPV/2. Since VAB is clamped to zero the current decreases. Now, the common-mode voltage is,

$$v_{AO} = v_{BO} = V_{PV}/2 \Rightarrow v_{cm} = V_{PV}/2.$$

In the negative half cycle, S2 and S3 are on. Again, S5 and S6 commutate at the switching frequency in order to modulate the input voltage. S1 and S4 commutate at the switching frequency together and complementarily to S5 and S6. In this situation, when S5 and S6 are on, VAB equals -VPV , and the inductor current, which now flows through S5,S3,S2, and S6 decreases. The common-mode voltage is,

$$v_{cm} = (v_{AO} + v_{BO})/2 = (0 + V_{PV})/2 = V_{PV}/2.$$

When S5 and S6 are turned off S1and S2 and are turned on, the current splits into two paths. The first path consists of S3 and the freewheeling diode of S1, and the second of S2 and the freewheeling diode of S4. Consequently, S1 and S4 are turned on with no current, so no switching losses appear. In this situation, voltages VAB and VCD tend to zero and diodes D7 and D8 fix the voltages VA0 and VB0 toVPV/ 2. The current decreases because VAB is clamped to zero. Now, the common-mode voltage is

$$v_{AQ} = v_{BQ} = V_{PV}/2 \Rightarrow v_{cm} = V_{PV}/2.$$

It is clear that the common-mode voltage remains constant during the four commutation states of the converter. Therefore, no varying common-mode voltage is generated by the proposed topology and, hence, no leakage currents appear. The common-mode voltage remains constant during all commutation states. Additionally, voltage , and therefore the inductor current, have the same waveforms as those obtained in the unipolar PWM full bridge. The zero-voltage state is realized using a bidirectional switch This bidirectional switch is made up of two insulated-gate bipolar transistors (IGBTs) and two diodes (S7 and S8). During the positive halfwave of the load (grid) voltage, S8 is switched on and is used during the freewheeling period of S1 and S4. On the other hand, during the negative half-wave, S7 is switched on and is used during the freewheeling period of S2 and S3. This way, using S7 or S8 the zero-voltage state is realized by short-circuiting the output of the inverter, during which period the PV is separated from the grid, because S1–S4 or S2–S3 are turned off. The output voltage of the inverter has three levels and the load current ripple is very small, although, in this case, the frequency of the current is equal to the switching frequency. The inverter generates no common-mode voltage; therefore, the leakage current through the parasitic capacitance of the PV would be very small.Assuming unity power factor, and commutate at the switching frequency with half of the input voltage , and the corresponding two freewheeling diodes of the full bridge commutate with but with half of the current. Therefore, switching losses will be lower than those of the bipolar PWM full bridge and can be expected to be similar to those of the unipolar PWM full bridge. Since the blocking voltage of and is only half of the input voltage, switches with lower rated blocking voltage can be used and thus will exhibit lower switching losses for the same operating conditions.

IV RESULTS AND DISCUSSION

The dc voltage generated in the photovoltaic array is simulated for 440 volt is applied to the inverter and the result is analyzed with the resistive load(normally the grid system consist of unity power factor so the resistive load is used for simulation analysis). This simulation model consist of the PV arrays and an parasitic capacitance two MOSFET switches with an freewheeling diodes is linked with an PWM inverter, the output is linked to an load along with the HERIC circuit and the filter across the terminal. The waveform is obtained from different part of the model and shown below. The output voltage is obtained across the load consist of low distortion

The leakage current obtained from the midpoint of the load is minimized(Zero), as the ground leakage current is Zero the losses in the system will be minimum. The common mode voltage is obtained across the inverter output is constant and no varriying common mode voltage is generated in the proposed topology and similarly no leakage current appears in the topology. The constant common mode voltage waveform is shown below.

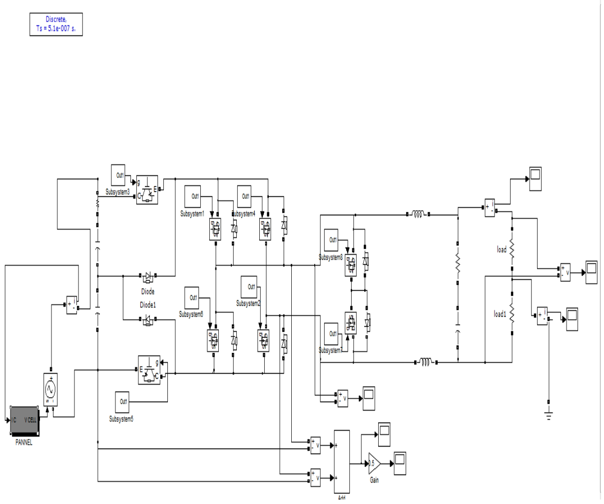

Fig 3. Simulation of Proposed Method

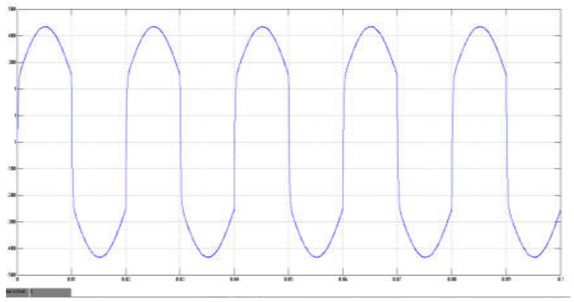

Fig. 4. Output Voltage

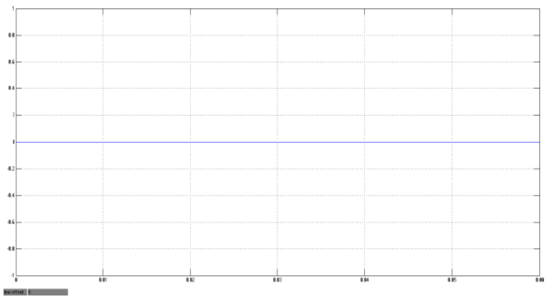

Fig. 5.Ground leakage current

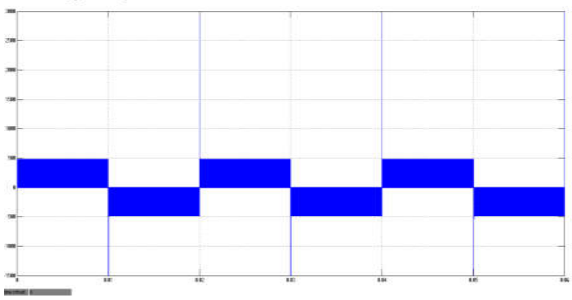

Fig. 5. Common Mode Voltage

CONCLUSION

In the proposed topology by the use of switches and diodes between the PV arrays Parasitic capacitance and inverter. Along with the use of Heric and filter circuit in the AC side of circuit an ripple free output voltage along with the low ground leakage current and the common mode voltages are obtained. By this method an grid connected transformerless single phase PV inverter isolation get improved. Similarly, system overall efficiency get improved. Hence the proposed method is simulated and the output are verified.

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