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Review on Transformer less PV Grid Connected Full-Bridge Inverter Topology with Constant Common-Mode Voltage

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Abstract: *Transformer less inverters are widely used in grid-tied photovoltaic (PV) generation systems, due to the benefits of achieving high efficiency and low cost. Various transformer less inverter topologies have been proposed to meet the safety requirement of leakage currents, such as specified in the VDE-4105 standard. In this thesis, a family of H6 transformer less inverter topologies with low leakage currents is proposed, and the intrinsic relationship between H5 topology, highly efficient and reliable inverter concept (HERIC) topology, and the proposed H6 topology has been discussed as well. One of the proposed H6 inverter topologies is taken as an example for detail analysis with operation modes and modulation strategy. The power losses and power device costs are compared among the H5, the HERIC, and the proposed H6 topologies. A universal prototype is built for these three topologies mentioned for evaluating their performances in terms of power efficiency and leakage currents characteristics. Experimental results show that the proposed H6 topology and the HERIC achieve similar performance in leakage currents, which is slightly worse than that of the H5 topology, but it features higher efficiency than that of H5 topology*

Keywords: Photovoltaic (PV), highly efficient and reliable inverter concept (HERIC)

I. INTRODUCTION

The applications of distributed photovoltaic (PV) generation systems in both commercial and residential structures have rapidly increased during recent years. Although the price of PV panel has been declined largely, the overall cost of both the investment and generation of PV grid-tied system are still too high, comparing with other renewable energy sources. Therefore, the grid-tied inverters need to be carefully designed for achieving the purposes of high efficiency, low cost, small size, and low weight, especially in the low-power single-phase systems (less than 5kW). From the safety point of Transformer less inverters are widely used in grid-tied photovoltaic (PV) generation systems, due to the benefits of achieving high efficiency and low cost. Various transformer less inverter topologies have been proposed to meet the safety requirement of leakage currents, such as specified in the VDE-4105 standard. In this paper, a family of H6 transformer less inverter topologies with low leakage currents is proposed, and the intrinsic relationship between H5 topology, HERIC topology and proposed H6 topology has been discussed as well. One of the proposed H6 inverter topologies is taken as an example for detail analysis with operation modes and modulation strategy. The power losses and power device costs are compared among the H5, the HERIC and the proposed H6 topologies. A universal prototype is built for these three topologies mentioned for evaluating their performances in terms of power efficiency and leakage currents characteristics. Experimental results show that the proposed H6 topology and the HERIC achieve similar performance in leakage currents, which is slightly worse than that of the H5 topology, but it features higher efficiency than that of H5 topology.

II. LITERATURE SURVEY

[1].In this paper a Transformer less inverters are widely used in grid-tied photovoltaic (PV) generation systems, due to the benefits of achieving high efficiency and low cost. Various transformer less inverter topologies have been proposed to meet the safety requirement of leakage currents, such as specified in the VDE-4105 standard. In this paper, a family of H6 transformer less inverter topologies with low leakage currents is proposed, and the intrinsic relationship between H5

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[2] Transformer less inverters are widely used in grid-tied photovoltaic (PV) generation systems, due to the benefits of achieving high efficiency and low cost. Various transformer less inverter topologies have been proposed to meet the safety requirement of leakage currents, such as specified in the VDE-4105 standard. In this paper, a family of H6 transformer less inverter topologies with low leakage currents is proposed, and the intrinsic relationship between H5 topology, highly efficient and reliable inverter concept (HERIC) topology, and the proposed H6 topology has been discussed as well. One of the proposed H6 inverter topologies is taken as an example for detail analysis with operation modes and modulation strategy. The power losses and power device costs are compared among the H5, the HERIC, and the proposed H6 topologies. A universal prototype is built for these three topologies mentioned for evaluating their performances in terms of power efficiency and leakage currents characteristics. Experimental results show that the proposed H6 topology and the HERIC achieve similar performance in leakage currents, which is slightly worse than that of the H5 topology, but it features higher efficiency than that of H5 topology.

[3] Many inverter topologies have been proposed to eliminate the leakage current of transformer less Full Bridge Grid-Tied photovoltaic (PV) inverters. These include implementations such as the H5, H6, and HERIC topologies, among others. In this paper, a new full bridge topology synthesis method, called the MN synthesis method, is proposed. The MN method introduces two criteria that can be used to synthesize all of the possible topologies, including the existing topologies as well as new simplified topologies. This method concludes that there are only 15 simplified topologies available. Most simplified topologies from MN method have been verified by existing papers and patents.

[4] In this paper, To eliminate the common-mode leakage current in the transformerless grid-connected photovoltaic (PV) system, inspired by the newly-developed embedded-switch H5 topology and dual-buck full-bridge grid-connected inverter (GCI), a novel transformerless dual-buck full-bridge GCI with H5-type (TDFGI-H5) topology for PV systems is firstly presented. Then, the operating modes and common-mode leakage current of TDFGI-H5 modulated by unipolar sinusoidal pulse-width modulation are analysed. The analysis result shows that TDFGI-H5 has the advantages of the three-level output, no shoot-through problem, high reliability, and can completely meet the condition of eliminating common-mode leakage current. Aim at the problem of the common-mode leakage affected by the switches' junction capacitances, the effect of switch's junction capacitance is explored in detail when TDFGI-H5 is in the transient process that converts from non-decoupling states to decoupling states. Finally, the results of experiment verify the correctness of the theoretical analysis

[5] This paper Efficiency and leakage current are two major issues for transformer less grid-connected inverters (TLI). Soft-switching technologies can reduce switching losses and be applied in TLIs. Herein, a zero-voltage-transition H5 type (ZVT-H5) inverter with soft turn-on and turn-off transitions of high-frequency main switches is derived from basic resonant tanks. Compared with the hard-switching H5 (HS-H5) inverter, the conversion efficiency of ZVT-H5 is significantly improved. Moreover, the reverse recovery problem of freewheeling diodes is alleviated under the operation of the auxiliary resonant network. Meanwhile, a diode clamping branch is employed to achieve constant common-mode characteristic for the ZVT-H5. The construction process of the proposed topology is described, and the operation principle of the auxiliary resonant network is analysed. Moreover, the resonant parameter design of ZVT-H5 and its circuit performance are discussed in detail. Finally, the experimental results of a 3-kW prototype at 100 kHz switching frequency are provided to verify the effectiveness of the ZVT-H5.

III. PROBLEM FORMULATION

A. Existing System

Exiting system with H5 transformer less system available but is the most versatile device. In summary, the H5 topology has the best leakage current characteristic, but its efficiency is the lowest.

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B. Proposed System

Proposed system introduces a new concept In this paper, a family of novel H6 full-bridge topologies is proposed for the transformer less PV grid-tied inverters. An extra switch is inserted to the H5 topology for forming a new current path and for the purpose of reducing conduction loss. Therefore, in the active modes, the inductor current of the proposed H6 topology flows through two switches during one of the half line periods, and flows through three switches during another half line period. The proposed H6 topology has achieved the minimum conduction loss, and also has featured with low leakage current.

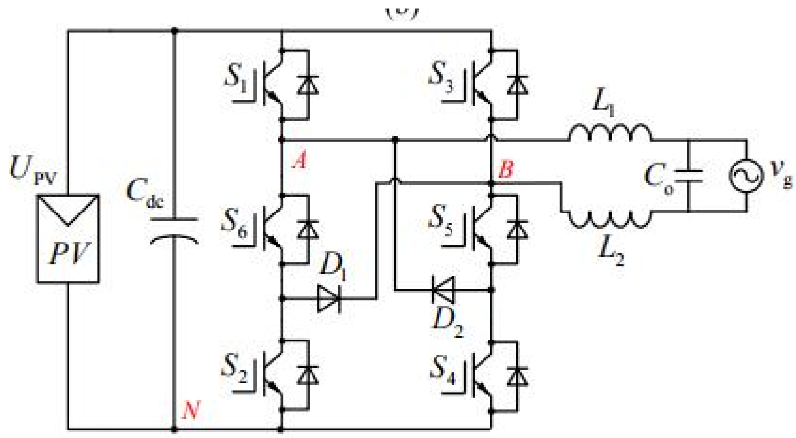

Fig1 : Proposed Topology

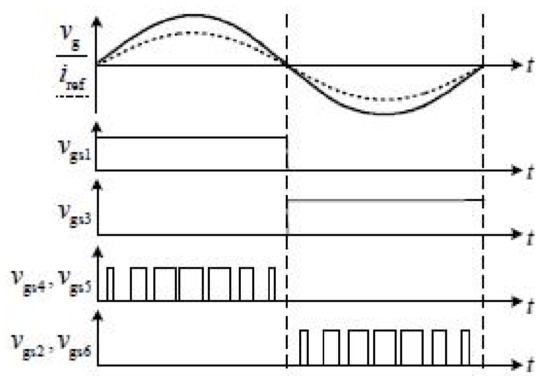

Fig. 2. Schematic of gate signal with unity power factor

C. Operation Mode Analysis

The circuit structure of proposed novel H6 inverter topologies shown in Fig. 4.10(a) is taken as an example to analysis. PV grid-tied systems usually operate with unity power factor. The waveforms of the gate drive signals for the proposed novel H6 topology are shown in Fig. 4.11, where vg is the voltage of utility grid. iref is the inductor current reference. Vgs 1 to vgs 6 represent the gate drive signals of switches S1 to S6, respectively. There are four operation modes in each period of the utility grid, as shown in Fig. 4.2, where Van represents the voltage between terminal (A) and terminal (N), and Vbn represents the voltage between terminal (B) and terminal (N), Vab is the differential-mode voltage of the topology, Vab = Van+Vbn The CM voltage VCM = 0.5(Van+Vbn).

a) Mode I is the active mode in the positive half period of the utility grid voltage, as shown in Fig. 4.12(a). S1, S4, and S5 are turned ON, and the other switches are turned OFF. The inductor current is flowing through S1, S4, and S5. Van = UPV, Vbn = 0, thus, Vab = UPV, and the CM voltage VCM = (Van+Vbn)/2 = 0.5 UPV.

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b) Mode II is the freewheeling mode in the positive half period of the utility grid voltage, as shown in Fig. 4.12(b). S1 is turned ON, the other switches are turned OFF. The inductor current is flowing through S1 and the anti-paralleled diode of S3. Van = Vbn ≈ 0.5 UPV, thus, Vab = 0, and the CM voltage VCM = (Van+Vbn)/2 ≈ 0.5 UPV.

(c) Mode III is the active mode in the negative half period of the utility grid voltage, as shown in Fig. 4.12(c). S2, S3, and S6 are turned ON, the other switches are turned OFF. The inductor current is flowing through S2 and S6. Although S3 is turned ON, there is no current flowing through it, and the switch S3 has no conduction loss in this mode. Nevertheless, in the H5 topology, the inductor current flows through S2, S3, and S5. Therefore, the conduction loss of proposed topology is less than that of H5 topology. In this mode, Van = 0, Vbn = UPV, thus, Vab = -UPV, and the CM voltage VCM = (Van+Vbn)/2 = 0.5 UPV.

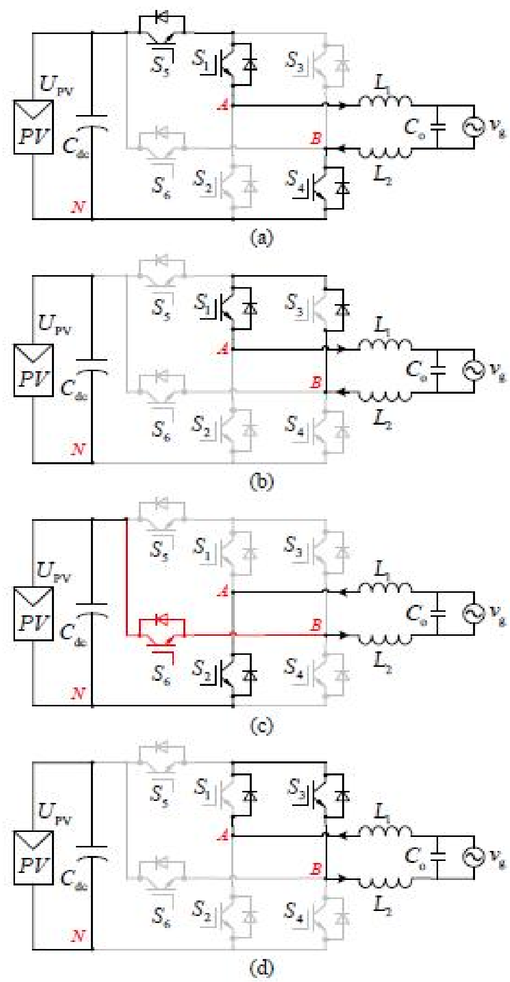

Fig. 3. Equivalent circuit of operation mode in the positive half period. (b) Freeheeling mode in the positive half period. (c) Active mode in the negative half period. (d) Freeheeling mode in the negative half period.

Mode IV is the freewheeling mode in the negative half period of the utility grid voltage, as shown in Fig. 3(d). S3 is turned ON, and the other switches are turned OFF. The inductor current is flowing through S3 and the anti-paralleled diode of S1. vAN = vBN ≈ 0.5 UPV, thus, vAB = 0, and the CM voltage VCM = (vAN+vBN)/2 ≈ 0.5 UPV. Based on the above analysis, the PV array can be disconnected from the utility grid when the output voltage of the proposed H6 inverter is at zero voltage level, and the leakage current path is cut off. The CM voltage of the proposed topology in each operation mode is equals to 0.5 UPV, and it results in low leakage current characteristic of the proposed H6 topologies. The proposed H6 topology with unipolar SPWM method not only can achieve unity power factor, but also has the ability to control the phase shifts between voltage and current waveforms.

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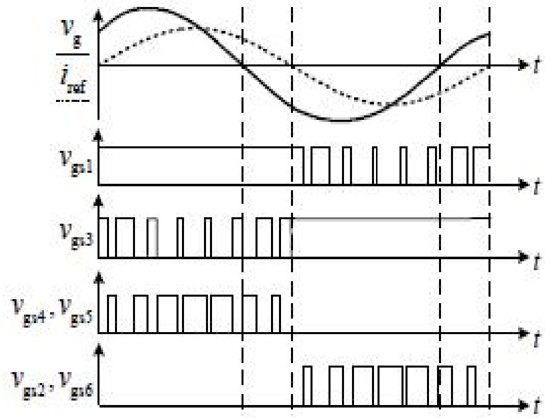

Fig. 4. Schematic of gate drive signals with power factor other than unity

The modulation strategy is shown in Fig. 4. The drive signal is in phase with the grid-tied current. Therefore, it has the capability of injecting or absorbing reactive power, which meets the demand for VDE-4105 standard

IV. Research Objectives

1. Main objective of project to Design grid tied PV system
2. To Design Transformer less H6 bridge Inverter
3. To minimize conduction Loss.
4. To Reduce harmonics using H6 full bridge Inverter Topology.

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