IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 2, May 2024

Review on Close Loop Control of Novel Transformer Less Inverter Topology for Single Phase Grid Converter

Harshal Dharpal[1], Kiran M. Kimmatkar[2], Manjeet Sakhare[3]
Students, Department of Electrical Engineering[1]
Assistant Professor, Department of Electrical Engineering[2,3]
Vidarbha Institute of Technology, Nagpur, Maharashtra, India

Abstract*: The continuous urge for improvement in our standard of living has increased the consumption of electrical energy by leaps and bounds. This hike in energy consumption, draining of fossil fuels and degrading global environment has led to invention of green power generation systems. Thus, the global demand for renewable resources has led to flourishing of photovoltaic (PV) market. The enabling technology in the PV systems is the inverter, which could be either: 1) with transformer isolated or 2) without transformer non-isolated (transformer-less inverter). Recently, single phase transformerless voltage source inverters (VSI) have been extensively used for distributed photovoltaic grid tied systems. The objective of this paper is to review a few notable topologies and propose a new topology for transformer-less photovoltaic inverter. The analysis and design of the proposed topology is verified by simulating it on PSIM. Furthermore, the simulation results are validated by testing a proof-of-concept laboratory hardware prototype rated at 250 W. Keywords— Photovoltaic (PV) systems, transformer-less, single phase inverter*

Keywords: Photovoltaic (PV), Transformer less, Inverter

I. INTRODUCTION

The increasing population and restricted amount of conventional natural resources like fossil fuels has made it necessary to obtain energy from unconventional sources, especially like the sun as it is unlimited, free and lacks any contaminants. With help from government incentive scheme and decrease in charges of photovoltaic (PV) module play a vitally important in distributed power generation. The evaluation of the grid-tied PV systems is enhanced by the progress in power convertors. In present two kinds of grid connected PV systems are available: one that uses a transformer and the other that does not. For security purpose with galvanic isolation, most of PV systems are built-up with transformer. Because of galvanic isolation, DC current does not inserted into grid. The current leakage within PV system and power grid is reduced by galvanic isolation. The high-frequency power transformer is used on DC side and at inverter's output side low frequency power transformer is used. The transformers costly though and also decrease the total frequency of the cycle of power conversion. Transformer-less (TL) PV system is provided to resolve these difficulties and is slightly lighter, inexpensive and high efficiency developed [7]. There is shortage of natural sources such as fuel and coal whereas on the other side there is rapid increment in human population [13]. To address this issue a best and genuine natural option is solar energy which is free from pollution. Grid linked with PV system play main role in distributed (DB) power generation because of low price of photovoltaic module and more number of government incentives.

Apart from these factors, progress in power electronics and semiconductor technology help in development of grid connected PV system The energy amount and payback time are totally dependent on reliability and efficiency of inverter, in case of PV systems that are grid connected In the approach we have taken, unipolar pulse width modulation control is used by transformer-less PV inverter because which ground leakage current is reduced and efficiency is increased [6]. In this project, analysis, modeling, simulation and implementation of the closed loop operation of a novel inverter topology suitable for transformer-less grid connected application is presented. The advantages of the proposed inverter topology are: (i) Elimination of ground leakage current; (ii) Buck-boost capability; (iii) Long operational life; (iv) Extraction of maximum power from PV array; (v) Low THD of the output current and (vi) Low dc injection into the grid. The effectiveness of the proposed inverter topology is verified with the help of simulations. Modeling of the inverter, small signal analysis (SSA), controller design, MPPT and Phase Locked Loop (PLL) using inverse Park transformation will be simulated in MATLAB 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 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.

[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 VDE4105 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 transformer less 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 transformer less 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 analyzed. 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. COMPARATIVELY ANALYSIS ON EXISTING TOPOLOGIES

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. The H6 topology has the best performance about leakage current suppression in existing single-phase full-bridge transformer see topologies but high leakage current.

Operation modes of H5 and HERIC

The operation modes of H5 topology and HERIC topology are taken as examples for analysis. There are four operation modes in each period of the utility grid of the H5 topology, as shown in Fig. 4.6. It can be seen that in the active modes, the inductor current of H5 topology is always flowing through three switches due to its extra switch S5 in DC side. In the freewheeling modes, the inductor current of H5 topology is flowing through two switches. There are four operation modes in each period of the utility grid of the HEIRC topology, as shown in Fig. 4.6(b). It can be seen that the inductor current of HERIC topology is always flowing through two switches in the active modes. In the freewheeling modes, the inductor current of HERIC topology is flowing through two switches. Therefore, although the H5 topology features less power devices than the HERIC topology, its conduction loss is higher than that of the HERIC topology. Moreover, the conduction losses of the H6-type topology and the Hybrid-bridge topology are also higher than that of the HERIC topology due to extra switches in the DC side. As a result, the conduction losses of H5 topology, H6-type topology and Hybrid-bridge topology should be reduced for the harvest of higher efficiency.

B. Topology Relationship

The H6-type topology is taken as an example to analysis first. From Fig. 4.6(c), it can be seen that there are two switches between the terminal (A) and the negative terminal of the PV array, and there are another two switches between the terminal (B) and the negative terminal of the PV array.

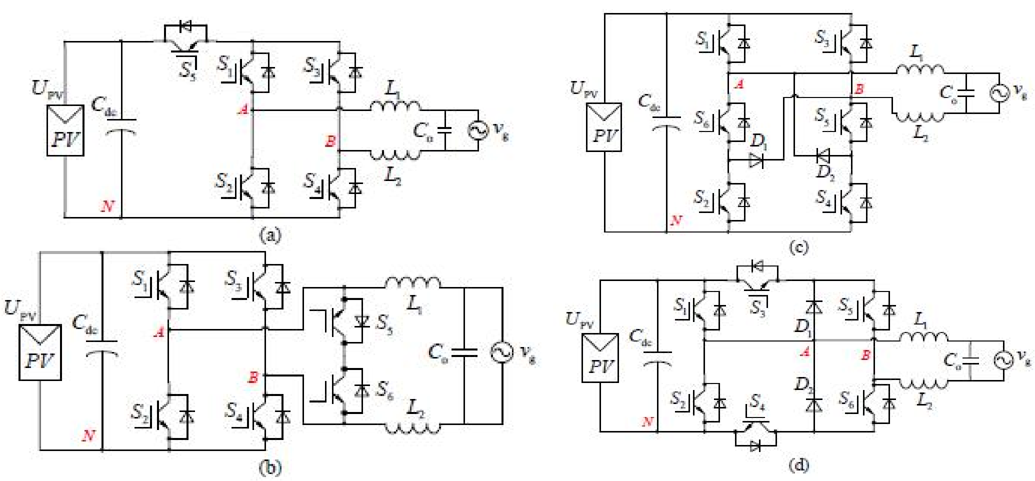

Fig. 4.4. Four typical topologies of transformerless full-bridge inverter. (a) H5. (b) HEIRC. (c) H6-type. (d) Hybride-bridge.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 2, May 2024

Therefore, the inductor current is controlled to flow through three switches in the active modes of H6-type topology. In order to reduce the conduction loss, the collector of switch S2 is disconnected from the anode of diode D1, and then it is connected to the terminal (A), as 0 shown in Fig. 4.7(a). As a result, the inductor current flows through S2 and S3 instead of S2, S3 and S6 in the active mode during the negative half cycle of the grid voltage. The DC and AC sides of this topology are still disconnected in the freewheeling modes. The same means are applied to another leg, where the switch S4 is disconnected from the diode D2 and then connected to the terminal (B), as shown in Fig. 4.7(b).

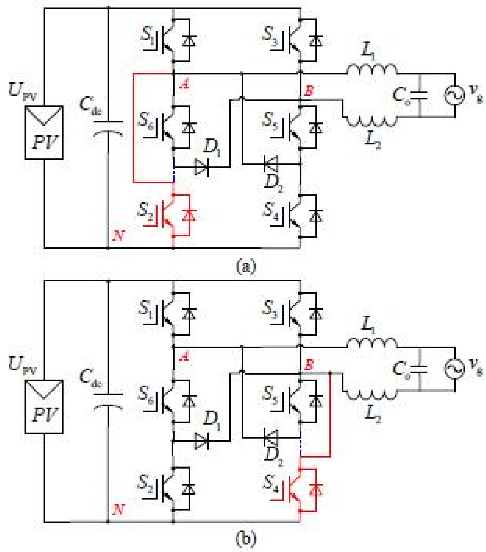

Fig. 4.6. Modified H6-type inverter topologies (a) Circui structure (b) Circuit structure

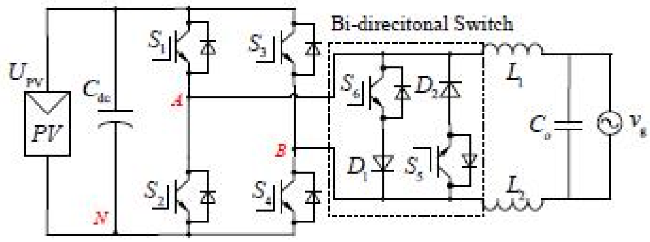

Fig. 4.7. Another circuit structure of HERIC topology

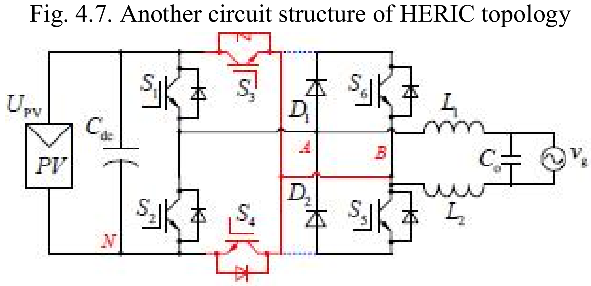

Fig. 4.8Another circuit structure of HERIC topology derived from Hybride-bridge topology

Hence, a circuit structure of HERIC topology is derived by the methods described in Fig. 4.7. The topology is shown in Fig. 4.8. Compared with the HERIC topology shown in Fig. 4.6(c), the form of the bi-directional switch in AC side is changed. Similarly, another circuit structure of HERIC topology can be derived from the Hybrid-bridge shown in Fig. 4.6(d). The switches S3 and S4 are disconnected from D1 and D2 respectively, and then connect both of them to the terminal (B), as shown in Fig. 4.9. However, there is only one extra switch in DC side of the H5 topology. When the emitter of S5 is disconnected from S1 and connected to the terminal (A), the inductor current flows through S4 and S5

IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

Impact Factor: 7.53

Volume 4, Issue 2, May 2024

instead of S1, S4 and S5 in the active mode of positive half cycle of the grid voltage. Hence, the conduction loss is reduced. Unfortunately, in the active mode of negative half cycle of the grid voltage, there is no inductor current path, as shown in Fig. 4.9. Therefore, an extra switch S6 is introduced into the topology between the positive terminal of the PV array and the terminal (B) to form a new current path. As a result, the circuit structure of the HERIC topology shown in Fig. 4.6(b) is derived from the H5 topology, as shown in Fig. 4.9. Therefore, we can derive various HERIC topologies based on the existing topologies, such as the H6-type topology, Hybrid-bridge topology and H5 topology, for the purpose of reducing conduction loss.

Analysis on the H6 topology and comparision with other topologies

A. Novel H6 Topology

From the analysis above, an extra switch S6 is introduced into the H5 inverter topology between the positive terminal of the PV array and the terminal (B) to form a new current path. As a result, a novel H6 transformerless full-bridge inverter topology is derived, as shown in Fig. 4.10(a). Similarly, the extra switch S6 can be introduced into the H5 inverter topology between the positive terminal of the PV array and the terminal (A) to form a new current path as well, as shown in Fig. 4.10(b). Therefore, a new circuit structure of novel H6 inverter is presented. As a result, the conduction loss of the proposed H6 topologies is higher than HERIC topology and less than H5 topology.

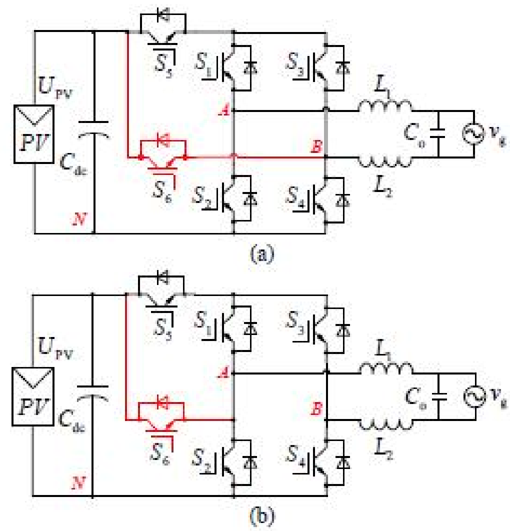

Fig. 4.9. A family of proposed H6-type inverter topologies. (a) Current structure (b) Circuit structure

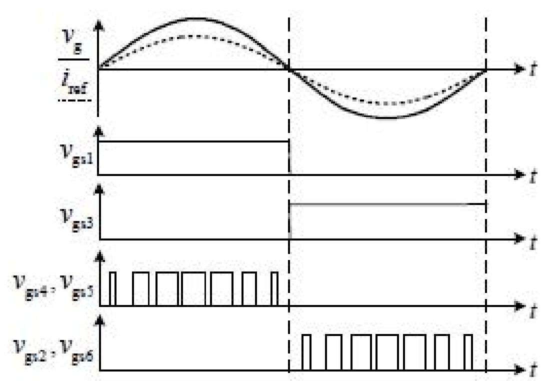

Fig. 4.10. Schematic of gate signal with unity power factor

Proposed System

In this project, analysis, modeling, simulation and implementation of the closed loop operation of a novel inverter topology suitable for transformer-less grid connected application is presented. The advantages of the proposed inverter topology are: (i) Elimination of ground leakage current; (ii) Buck-boost capability; (iii) Long operational life; (iv) Extraction of maximum power from PV array; (v) Low THD of the output current and (vi) Low dc injection into the grid.. The efficiency of presented TL inverter is more by comparing with existing TL inverter.

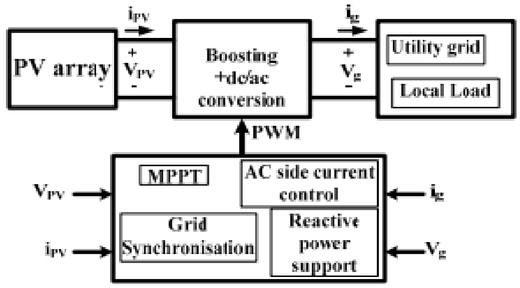

Fig1 : Proposed Topology

IV. RESEARCH OBJECTIVES

Main objective of project to Design grid tied PV system

- To minimize conduction Loss.
- To efficiency transformer-less inverter for grid tied PV system
- To minimises THD at output side using novel Inverter Topology.
- To Compare traditional topology with novel Tranformer less inverter Topology.

V. CONCLUSION

The work will presents a new high efficiency transformer-less inverter for grid tied PV systems. The key benefits of this research work in brief as:

1. Proposed converter will the overall efficiency.
2. By keeping common mode voltage fixed at center point of bus DC voltage due to this less leakage current will flow through the network than H6 topology.
3. The illustrated work, which minimizes THD at output side, does not require PWM dead time. bridge legs.

REFERENCES

[1] L. Zhang, K. Sun, Y. Xing and M. Xing, "H6 Transformerless Full-Bridge PV Grid-Tied Inverters," in IEEE Transactions on Power Electronics, vol. 29, no. 3, pp. 1229-1238, March 2014, doi: 10.1109/TPEL.2013.2260178.

[2] L. Zhang, K. Sun, Y. Xing and M. Xing, "H6 Transformerless Full-Bridge PV Grid-Tied Inverters," in IEEE Transactions on Power Electronics, vol. 29, no. 3, pp. 1229-1238, March 2014, doi: 10.1109/TPEL.2013.2260178.

[3] H. Wang, S. Burton, Y. Liu, P. C. Sen and J. M. Guerrero, "A systematic method to synthesize new transformer less full-bridge grid-tied inverters," 2014 IEEE Energy Conversion Congress and Exposition (ECCE), Pittsburgh, PA, 2014, pp. 2760-2766, doi: 10.1109/ECCE.2014.6953772.

[4] Y. Dai, W. Li, C. Zhou and S. Zhuang, "Research on transformerless dual-buck full-bridge grid-connected inverter with H5-type for PV systems," in IET Power Electronics, vol. 12, no. 1, pp. 44-50, 12 1 2019, doi: 10.1049/iet-pel.2018.5196.

[5] J. Fang, M. Shi, H. Xiao and R. Wang, "A Zero-Voltage-Transition H5-Type Transformerless Photovoltaic Grid-Connected Inverter," in IEEE Access, doi: 10.1109/ACCESS.2019.2946976.

[6] M. Islam, S. Mekhilef, and M. Hasan, "Single phase transformerless inverter topologies for grid-tied photovoltaic system: A review," Renewable and Sustainable Energy Reviews, vol. 45, pp. 69-86, 2015.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 2, May 2024

[7] Yong-Won, C., Woo-Jun, C., Jung-Min, K., et al.: 'Improved single-phase TL inverter with high power density and high efficiency for grid-connected photovoltaic systems', IET Renew. Power Gener., 2016, 10, (2), pp. 166–174 [15] Li,

[8]W., Gu, Y., Luo, H., et al.: 'Review and derivation methodology of single phase TL photovoltaic inverters for leakage current suppression', IEEE Trans. Ind. Electron., 2015, 62, (7), pp. 4537–4551.

[9] Jaber, F.A., Yam, P.S., Mehran, S., et al.: 'S4 gridconnected single-phase TL inverter for PV application'. IEEE Conf., 2016

[10] Yong-Won, C., Woo-Jun, C., Jung-Min, K., et al.: 'Improved single-phase TL inverter with high power density and high efficiency for grid-connected photovoltaic systems', IET Renew. Power Gener., 2016, 10, (2), pp. 166–174.