A Novel based Common Mode Current for Transformer-Less PV Grid Connected Inverter using H5-D Topology

Mrs. A. Sugasini Asst Prof/EEE
S. Meenaparameswari, R. Dhanasri, R. Kudiyarasu
Final Year EEE
Dhanalakshmi Srinivasan Engineering College,
Perambalur

Abstract:- **An improved H5 topology, namely H5-D topology, is proposed, in which a clamping diode is added on the basis of H5 topology to eliminate the common-mode voltage fluctuation in H5 topology. Further, the PSIM simulation results of the H5-D topology and H5 topology are given and compared, especially; the performance of H5-D topology for common-mode current suppression is presented and analyzed concretely. Finally, the experimental prototypes of the H5-D topology and H5 topology are built and tested, and the experimental results validate the advantages of the H5-D topology. The proposed H5-D topology provides a new practical topology for distributed photovoltaic grid-connected power generation systems.**

INTRODUCTION

Photovoltaic (PV) grid-connected inverters fall into two categories, namely transformer isolation PV inverters and transformer less PV inverters. The transformer less PV inverters have the advantages on small size, low cost and high efficiency compared with the transformer isolation PV inverters. However, the common-mode (CM) currents of the transformer less PV inverters could flow through the parasitic capacitor between the PV array and the ground, which will lead to serious electromagnetic interference and insecurity, and reduce the reliability of the PV inverter systems in practice, such as the hybrid energy storage systems. Therefore, the CM current suppression of transformer less PV inverters has become a hot issue in recent decades.

In order to eliminate or suppress CM current, lots of new topologies have been proposed for the transformer less PV inverters . In these topologies, the CM current is reduced by separating PV array away from the grid or by adding extra clamp circuit to keep CM voltage constant . For the methods of separating PV array away from the grid, some switches are added into the existing topologies, such as H5 topology, in which a switch is added between the input and the bridge arms . In oH5 topology, a switch branch is added between the input and the midpoints of bridge arms on the basis of H5 topology . In H6 family topologies, two switches are added between the input and the bridge arms, or just added into the bridge arms .

In HERIC family topologies, the extra freewheeling branch is added between the bridge arm and filter inductors. For the methods of adding extra clamp circuit, normally a clamp circuit will be added to clamp the midpoints voltage of the bridge arms, such as, the neutral clamp HERIC topology, in which a clamp circuit is added between the midpoint of input capacitors and freewheeling branch. In HERIC family topologies, the extra freewheeling branch is added between the bridge arm and filter inductors. For the methods of adding extra clamp circuit, normally a clamp circuit will be added to clamp the midpoints voltage of the bridge arms, such as, the neutral clamp HERIC topology, in which a clamp circuit is added between the midpoint of input capacitors and freewheeling branch. Also in HB-ZVR topology, a clamp circuit containing a switch and five diodes are added between the midpoint of input capacitors and the midpoint of bridge arms based on full-bridge topology.

OBJECTIVES

The objectives of our project are to reduce common mode leakage current and to improve efficiency.

EXISTING SYSTEM

CM current suppression of transformer less PV inverters

CM current suppression of transformer less PV inverters has become a hot issue in recent decades. In order to eliminate or suppress CM current, lots of new topologies have been proposed for the transformer less PV inverters. In these topologies, the CM current is reduced by separating PV array away from the grid or by adding extra clamp circuit Modulation strategies have been proposed to keep the CM voltage constant and reduce the CM current. For example, the bipolar modulation strategy was proposed to keep CM voltage constant for the full-bridge topology with four switches.

Bipolar modulation strategy

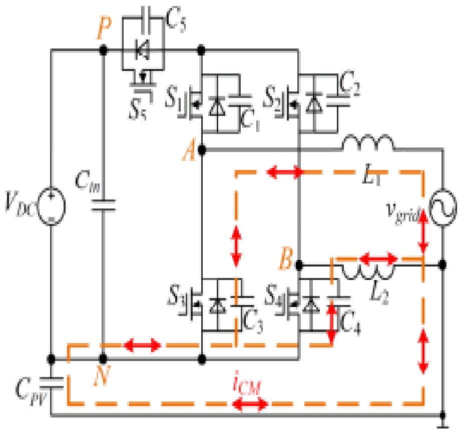
Modulation strategies have been proposed to keep the CM voltage constant and reduce the CM current. For example, the bipolar modulation strategy was proposed to keep CM voltage constant for the full-bridge topology with four switches. Unfortunately, in full-bridge topology with the bipolar modulation, high losses and double inductance are unavoidable due to the two-level bipolar output voltage.

Double-frequency SPWM strategy

ISSN: 2278-0181

The double-frequency SPWM strategy was proposed to keep CM voltage constant for the three-level output H6 topology. However, the modulation strategies are proposed for specific topologies, and these topologies are complicated because of the additional devices. Transformer-less inverters are increasing popularity in USA after European and Australian markets.

CIRCUIT DIAGRAM



DISADVANTAGES

- Insecurity
- Large electromagnetic interference process
- Reduce reliability process

PROPOSED SYSTEM

To effectively suppress CM current in the inverter with H5 topology, this paper provides an improved H5 topology, namely, H5-D topology H5-D topology and its modulation strategy for transformer less PV inverters are proposed in this paper, which can effectively suppress the CM currents of the PV inverters. And the proposed H5-D topology only includes five switches and a diode. Using the improved modulation strategy, the CM voltage of the inverter with H5-D topology can keep constant and the CM current is only about one-third of that with H5 topology in the case that using the same electrical parameters and power switches.

ADVANTAGES

- High efficiency
- Low cost process
- Effective suppression process

The Proposed H5-D Topology

To get the constant CM voltage, the H5-D topology is proposed, which is composed of five switches (1S – 5 S) and a clamping diode c D , as shown in Fig. 4. Where, in1 C ,in2 C and c D constitute the passive clamp circuit, and it is used to clamp the voltages of the bridge midpoints in H5-D topology. To introduce the operating principle of the proposed H5-D topology, its modulation strategy is also provided.

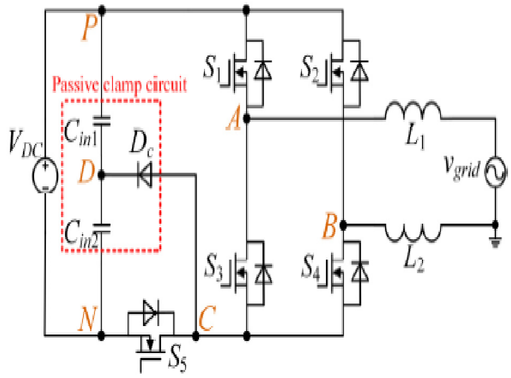


Figure 3.2 H5D topology circuit diagram

Modulation Strategy of H5-D Topology

According to the basic modulation strategy, the unipolar SPWM technique is employed in the proposed H5-D topology, which is shown in Fig. 5, where *c v* is carrier wave and *m v* is modulation wave. In the positive half period, 1 *S* and 5 *S* have the same driving signals, 1 *S* and 3 *S* have the opposite driving signals. In the negative half period, 2 *S* and 5 *S* have the same driving signals, 2 *S* and 4 *S* have the opposite driving signals.

Operating Modes of H5-D Topology

According to the operating principle of the proposed H5-D topology, there are six operating modes. In the positive half period of grid voltage, there are Mode 1, Mode 2 and Mode 6, and in the negative half period of grid voltage, there are Mode 3, Mode 4 and Mode 5, as shown in Fig. 6.

Mode 1: S_1,$S_4$and $S_5$are turned on

Mode 2: $S_1$and $S_5$are turned off, $S_3$and $S_4$are turned on

Mode 3: S_2, S_3 and $S_5$are turned on

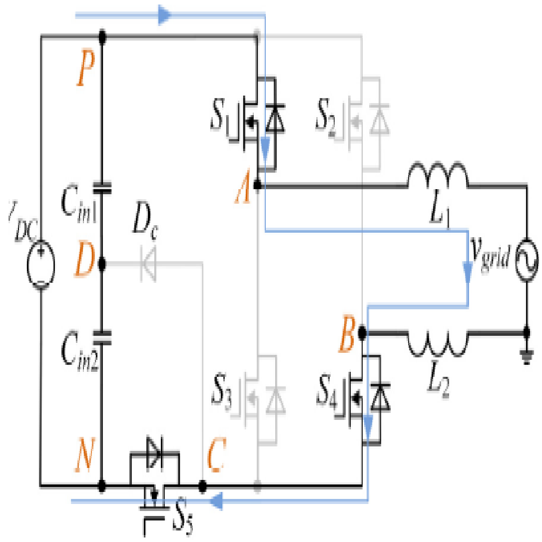
Mode 4: $S_2$and $S_5$are turned off, S_3 and S_4 are turned on

Mode 5: After the grid voltage crosses over the zero point from the positive half period, the current of filter inductors will continuously flow through the antiparallel diodes of S_2, $S_3$and S_5.

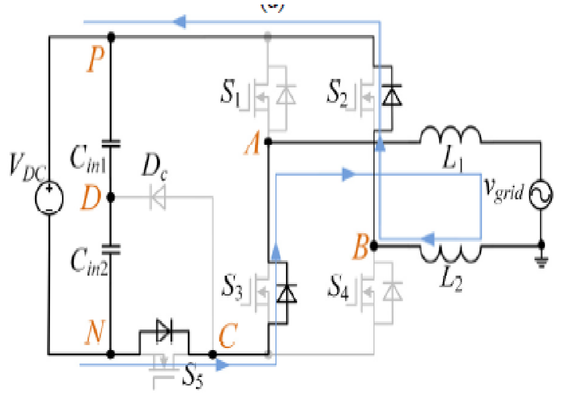
Mode 6: After the grid voltage crosses over the zero point from the negative half period, the current of filter inductors will continuously flow through the antiparallel diodes of S_1, S_4 and S_5.

Inductors will continuously flow through the antiparallel diodes of S_1, S_4 and S_5.

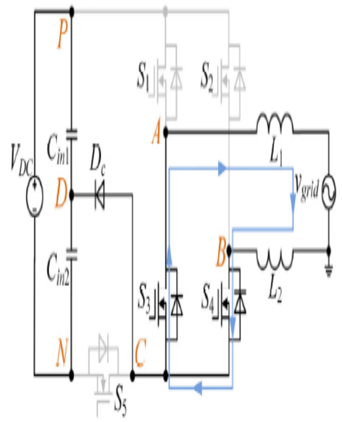
ISSN: 2278-0181



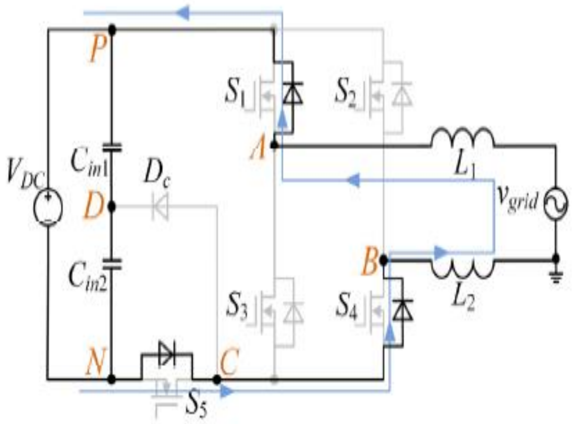
(a)



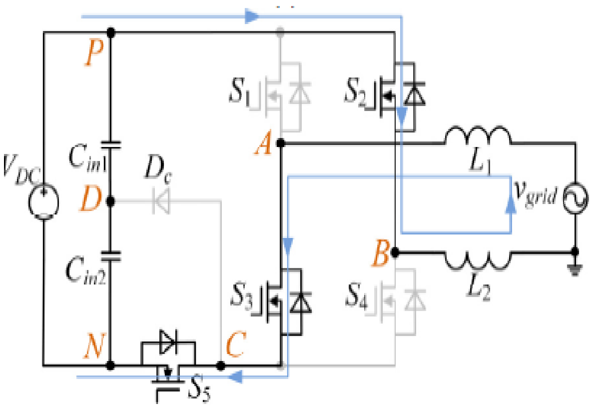
(C)

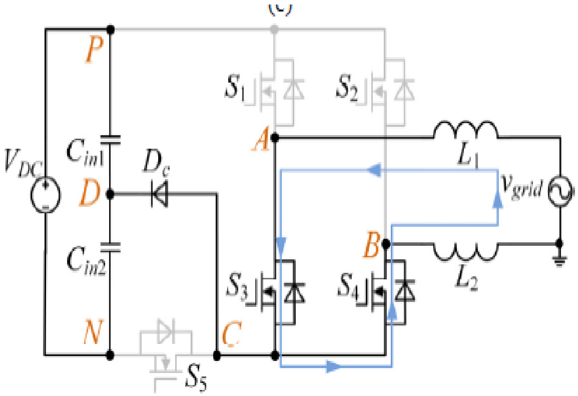


(b)



(d)





4 The control strategy of H5-D Topology

To verify the function of the proposed H5-D topology, the control strategy in [42] is adopted in this paper, as seen in Fig. It is a common control strategy for single phase inverter with proportional-resonant (PR) controller, where, the grid connected current, grid iis taken as the control variable, the grid voltage is sampled to obtain its phase and PR controller and SPWM are employed to get the required grid connected current.

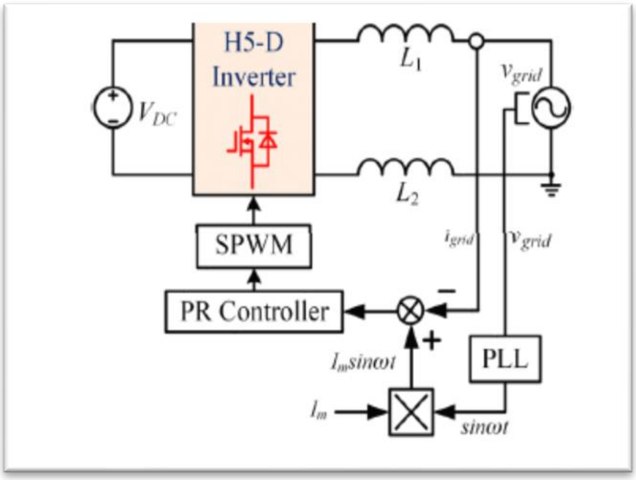
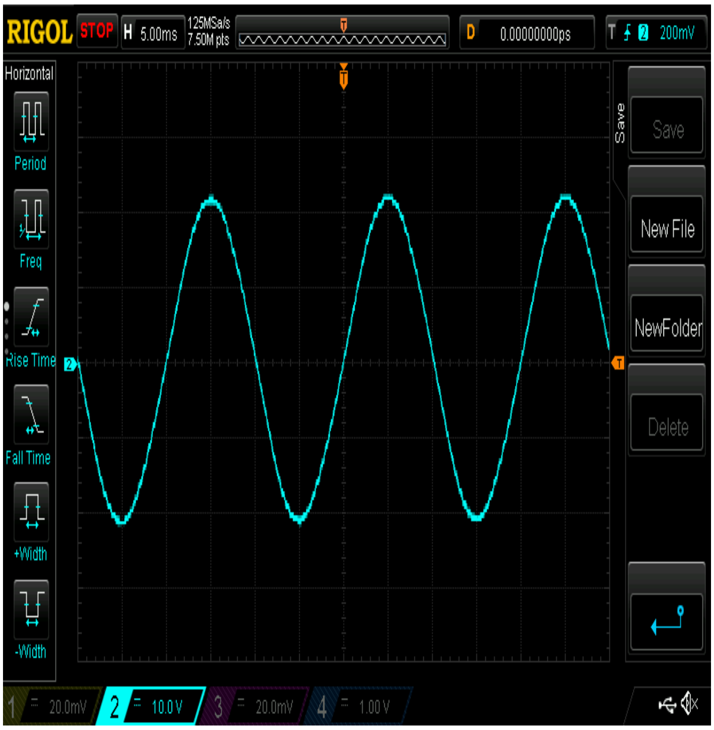
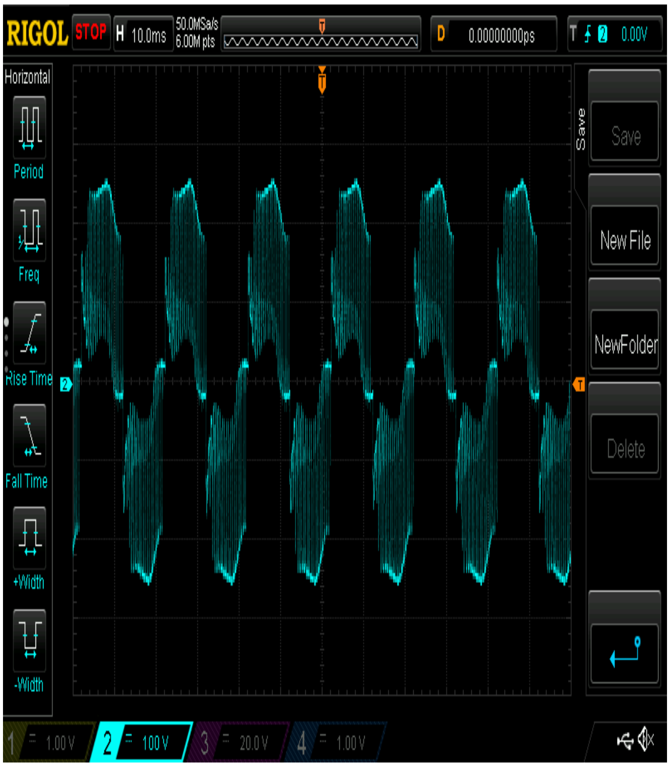
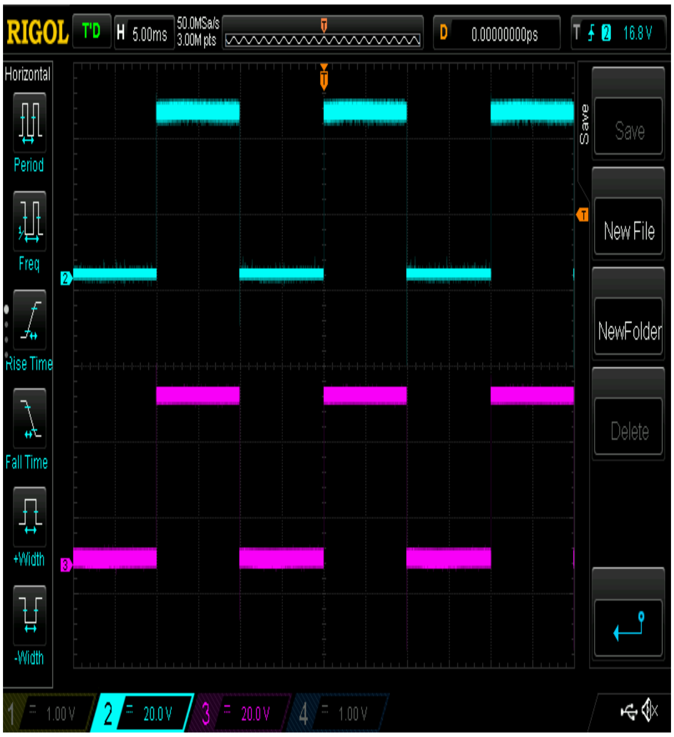


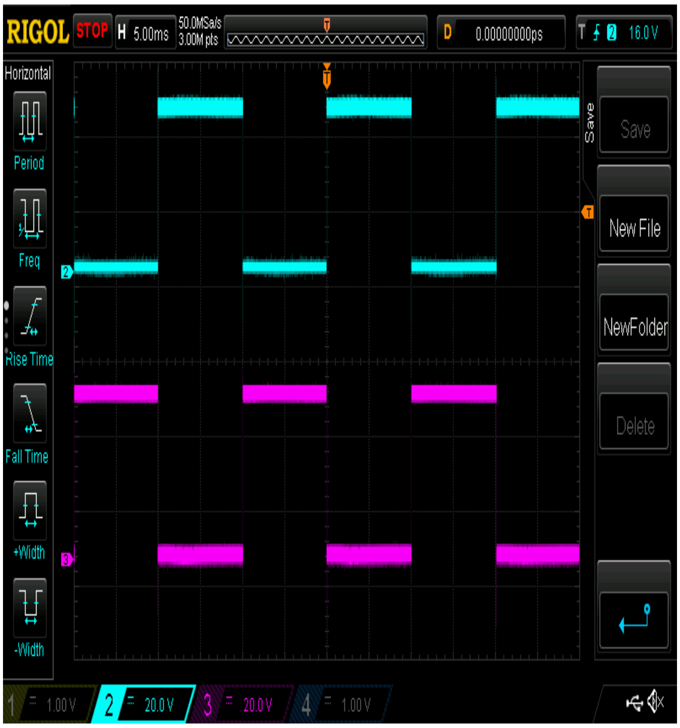
Figure 3.5 the control strategy H5 topology

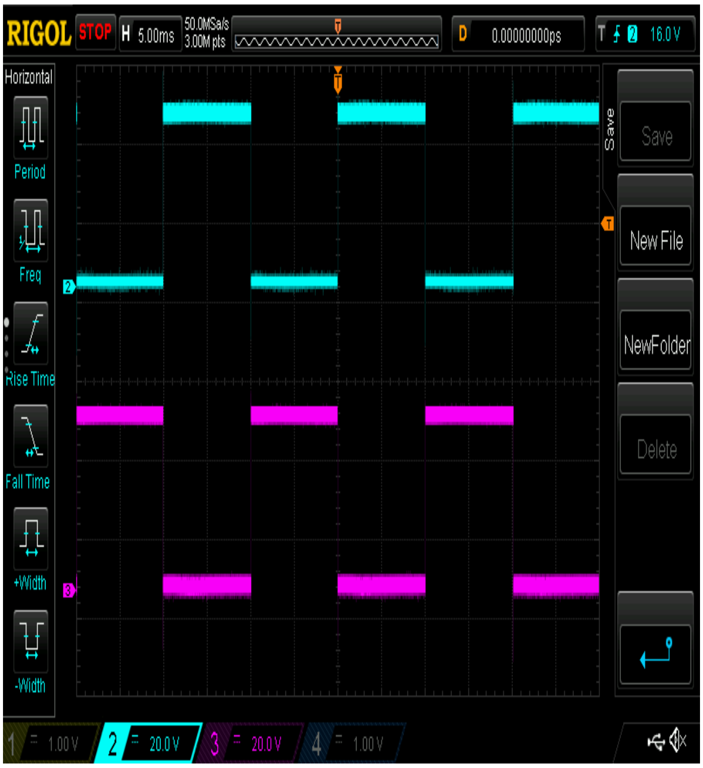
5.6 EXPERIMENTAL RESULTS OF H5D TOPOLOGY

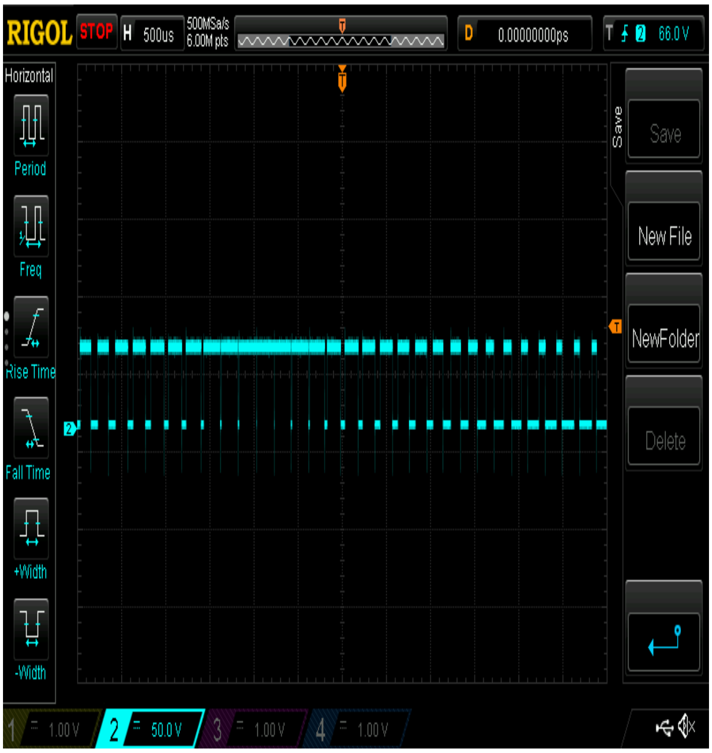












CONCLUSION

A H5-D topology and its modulation strategy for transformerless PV inverters are proposed in this paper, which can effectively suppress the CM currents of the PV inverters. And the proposed H5-D topology only includes five switches and a diode. Using the improved modulation strategy, the CM voltage of the inverter with H5-D topology can keep constant and the CM current is only about one-third of that with H5 topology in the case that using the same electrical parameters and power switches. The simulation and experimental results validate the effectiveness of the proposed H5-D topology and the correctness of the theoretical analysis in this paper. Therefore, H5-D topology provides a good choice for single phase transformer less PV inverters due to its simplicity and practicality.

REFERENCES

[1] R. González, J. López, P. Sanchis and L. Marroyo, "Transformerless inverter for single-phase photovoltaic systems," *IEEE Trans. PowerElectron.*, vol. 22, no. 2, pp. 693-697, Mar. 2007.

[2] R. González, E. Gubía, J. López and L. Marroyo, "Transformerless single-phase multilevel-based photovoltaic inverter," *IEEE Trans. Ind.Electron.*, vol. 55, no. 7, pp. 2694-2702, Jul. 2008.

[3] H. Jedtberg, A. Pigazo, M. Liserre, and G. Buticchi, "Analysis of the robustness of transformerless PV inverter topologies to the choice of power devices," *IEEE Trans. Power Electron.*, vol. 32, no.7, pp. 5248- 5257, Jul. 2017.

[4] R. R. de Lima, F. C. Melo, L. S. Garcia, E. A. A Coelho, V. J. Farias and L. C. G. Freitas, "Design and modeling of a transformerless hybrid inverter system using a fuel cell as energy storage element for microgrids with sensitive loads," *Proc. IEEE 6th Int. Symposium on Power Electron.for Distributed Generation Sys.*, Aachen, Germany, Jun. 2015, pp. 1-8.

[5] H. Xiao and S. Xie, "Leakage current analytical model and application in single-phase transformerless photovoltaic grid-connected inverter," *IEEE Trans. Electromagnetic Compatibility*, vol. 52, no. 4, pp. 902-913, Nov. 2010.

[6] L. S. Garcia, G. M. Buiatti, L. C. de Freitas, E. A. A. Coelho, V. J. Farias and L. C. Gomes de Freitas, "Dual transformerless single-stage current source inverter with energy management control strategy," *IEEE Trans.Power Electron.*, vol. 28, no. 10, pp. 4644-4656, Oct. 2013.

[7] V. Sonti, S. Jain and S. Bhattacharya, "Analysis of the modulation strategy for the minimization of the leakage current in the PV gridconnected cascaded multilevel inverter," *IEEE Trans. Power Electron.*, vol. 32, no. 2, pp. 1156-1169, Feb. 2017.

[8] W. Li, Y. Gu, H. Luo, W. Cui, X. He and C. Xia, "Topology review and derivation methodology of single-phase transformerless photovoltaic inverters for leakage current suppression," *IEEE Trans. Ind. Electron.*, vol. 62, no. 7, pp. 4537-4551, Jul. 2015.

[9] S. A. Khan, Y. Guo and J. Zhu, "A high efficiency transformerless PV grid-connected inverter with leakage current suppression," *Proc. 20169th Int. Conf. on Electric. and Computer Eng.*, Dhaka, Bangladesh, Dec. 2016, pp. 190-193.

[10] M. Victor, F. Greizer, S. Bremicker, and U. Hubler, "Method of converting a direct current voltage from a source of direct current voltage, more specially from a photovoltaic source of direct current voltage, into alternating current voltage," U.S. Patent 7 411 802 B2, Jun. 2005.

[11] H. Xiao, S. Xie, Y. Chen and R. Huang, "An optimized transformerless photovoltaic grid-connected inverter," *IEEE Trans. Ind. Electron.*, vol. 58, no. 5, pp. 1887-1895, May 2011.

[12] L. Zhang, K. Sun, Y. Xing and M. Xing, "H6 transformerless full-bridge PV grid-tied inverters," *IEEE Trans. Power Electron.*, vol. 29, no. 3, pp. 1229-1238, Mar. 2014.

[13] B. Ji, J. Wang and J. Zhao, "High-efficiency single-phase transformerless PV H6 inverter with hybrid modulation method," *IEEE Trans. Ind.Electron.*, vol. 60, no. 5, pp. 2104-2115, May 2013.

[14] W. Yu, J. S. J. Lai, H. Qian and C. Hutchens, "High-efficiency MOSFET inverter with H6-type configuration for photovoltaic non isolated ACmodule applications," *IEEE Trans. Power Electron.*, vol. 26, no. 4, pp. 1253-1260, Apr. 2011.

ISSN: 2278-0181
ICONEEEA - 2k19 Conference Proceedings

[15] M. Islam and S. Mekhilef, “H6-type transformerless single-phase inverter for grid-tied photovoltaic system,” *IET Power Electron.*, vol. 8, no. 4, pp. 636-644, Apr. 2015.
[16] W. Cui, B. Yang, Y. Zhao, W. Li and X. He, “A novel single-phase transformerless grid-connected inverter,” *Proc. 37th Annu. Conf. IEEEInd. Electron. Soc.*, Melbourne, VIC, Nov. 2011, pp. 1126-1130.
[17] H. Schmidt, C. Siedle, and J. Ketterer, “DC/AC converter to convert direct electric voltage in alternating voltage or into alternating current,” Patent 7 046 534 B2, Feb. 2004.
[18] S. Hu, C. Li, W. Li, X. He and F. Cao, “Enhanced HERIC based transformerless inverter with hybrid clamping cell for leakage current elimination,” *Proc. IEEE Energy Convers. Cong. and Expo.*, Montreal, QC, Sept. 2015, pp. 5337-5341.