

Comparison of H5 and HERIC Transformerless Inverter Topology Concerning Leakage Current and Efficiency for PV System

Sushama Meshram¹, Heena Sheikh²

¹PG Scholar, ²Assistant Professor

^{1,2}Dept. of Electrical Engineering, Ballarpur Institute of Technology, Balharshah, Maharashtra, India.

Abstract – The single phase photovoltaic transformer less inverter system it is connected to the grid, this system is mostly depends upon the filters. The filter are required because of there are no transformer are used. In this system we are studying about eliminating the common mode leakage current in the transformer less photovoltaic grid connected system. The main aim of this project is to compare between H5 and HERIC topologies. Also we are comparing the common mode leakage current of this two main topologies used in the system. So the main aim of this research is to compare the H5 and HERIC topologies and analyze the result for better output between this two topologies. In this topologies the universal bridge are design, that control with PWM pulses. The overall concept of the system is PV system are generate the voltage that voltage can boost using the boost converter and also system used another topologies that is maximum power point (MPP) because of the batteries efficiency are increase, and output of boost converter are given to the universal bridge inverter, and other part is filter, the output of inverter in given to filter because of no transformer are used. The design of transformer less inverter is based on the galvanic isolation method to eliminate the generation of leakage current. Unfortunately, the use of the galvanic isolation method alone cannot achieve constant common mode voltage (CMV). Therefore, a complete elimination of leakage current cannot be achieve. This system is studied and design using MATLAB Simulink software.

Key Words: Transformerless Inverter, Elimination of Leakage Current, reactive power; PV system, MPPT, H5, H6, HERIC.

1. INTRODUCTION

A few transformerless inverter topologies have been displayed and distributed. One of the downsides of PV transformerless inverters is the producing of leakage current because of the absence of a transformer. High generation of leakage current increases framework losses, total harmonic distortion (THD), electromagnetic interference (EMI) and can cause individual wellbeing issue. The writing refers to different balance methods that have been utilized to dispose of or limit leakage current.

Numerous transformerless inverter topologies with unipolar regulation method have been acquainted

with increment framework proficiency and reduce the leakage current by separating the AC and DC sides during the freewheeling modes; this is known as galvanic disconnection. Numerous topologies have been determined and created dependent on this technique, including an highly efficient and reliable inverter concept (HERIC), the H5 inverter and the H6 topology. However, total disposal of leakage current can't be accomplished with the galvanic separation technique alone in light of the fact that common mode voltage (CMV) during freewheeling periods can't be recognized by the exchanging state, which implies that it isn't consistent. Thusly, adjustment methodologies and converter structures must be changed so CMV winds up consistent during all inverter working modes.

The greater part of the regulation methods are intended for the utilization of a unity power factor. To be sure, next-generation PV inverters are required to help responsive capacity to consider the high penetration of PV inverters to be associated with the utility network. A few worldwide models have been evaluated to accomplish receptive power support. As revealed by VDE-AR-N4105, PV grid connected inverters must be able to produce reactive power.

Considering all this, a traditional bipolar modulation strategy is proposed as a conceivable possibility to be utilized in next-generation PV inverters, since it can produce reactive power and take out leakage current. All things considered, utilizing bipolar modulation procedures to produce reactive power will build increase switching losses and degrade system efficiency as it is a two-level modulation.

In this paper, WBG power devices, for example, SiC MOSFET are utilized to accomplish reactive power generation without adjusting or altering the structure of the circuit. Moreover, the total losses (switching and conduction) are essentially with SiC MOSFET because of its prevalent attributes. Also, high efficiency and low THD is accomplished when working the framework at high exchanging recurrence of 100 kHz with SiC MOSFET.

2. METHODOLOGY

A. MPPT:

This area covers the operation of "Maximum Power Point Tracking" as utilized as a part of solar electric charge controllers.

A MPPT, or maximum power point tracker is an electronic DC to DC converter that enhances the match between the solar based cluster (PV panels), and the battery bank or utility grid. Basically, they change over a higher voltage DC output from solar panels down to the lower voltage expected to charge batteries.

In this research utilized unipolar based Voltage source PWM (pulse width modulation) dc to ac inverter. With the goal that the state of the output is Square PWM wave. In this paper utilized this on the grounds that on the off chance that we pass this sort of flag in a low pass channel than we get sine wave which matches to the network.

array from the load during periods of zero output voltage of the inverter.

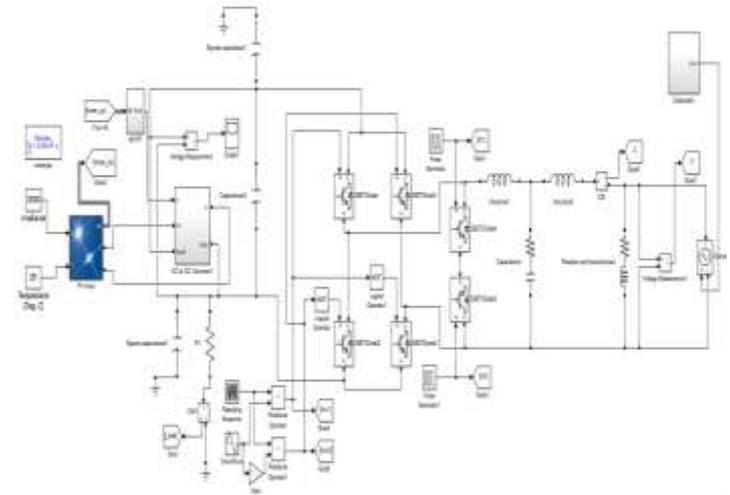


Fig.1. Simulink diagram of HERIC topology

C. Principle of operation of H5 inverter:

H5 transformer - less inverter consists of conventional H - bridge inverter in addition to only extra switch S5 as shown in Fig. 3. Although only one switch is added, this switch conducts during the two active modes. Therefore, three switches are always 'ON' in the active modes thus the conduction \ losses increase.

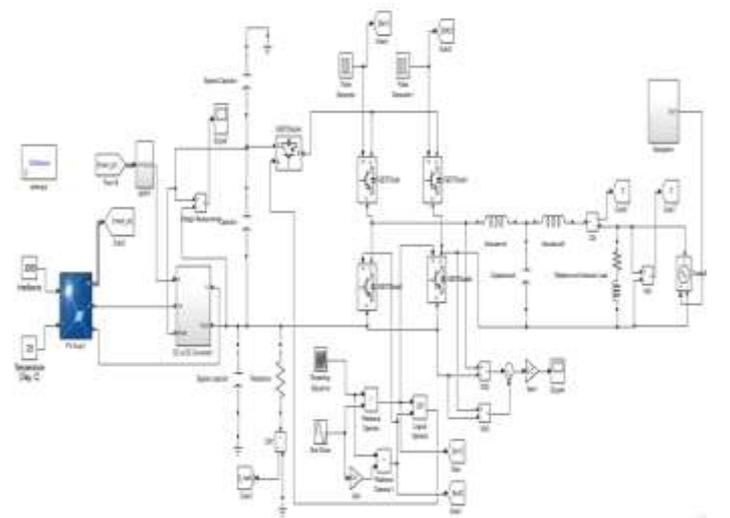


Fig.2. Simulink diagram of H5 topology.

D. Comparison between HERIC and H5 inverters

The comparison between the two inverters is based on three criteria; conduction losses, size of the required filter and amount of leakage current.

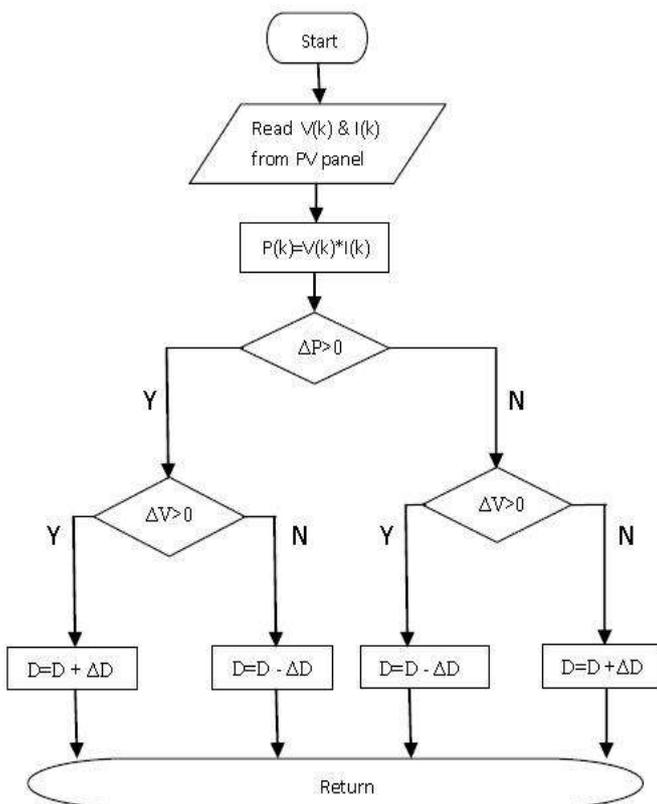


Fig. 4: Flow Chart of MPPT

B. Principle of operation of HERIC inverter:

HERIC transformer - less inverter consists of conventional H - bridge inverter in addition to two switches S5 and S6 as shown in Fig. 1. The switches S5 and S6 are connected in a reversed manner. The additional switches with their antiparallel diodes disconnect the PV -

I) Conduction losses

The average conduction losses of each switch, freewheeling diode conduction losses and total conduction losses for H5 and HERIC inverters respectively. It can be noticed that the conduction losses with HERIC inverter is lower than that of H5 inverter although six switches are used in HERIC inverters. The reason is that during active modes S5 always conducts in H5 inverter and as a results three switches always conduct in active modes. On the other hand, only two switches conducts in active modes with HERIC inverter. It is also noticed that the conduction losses when applying SHE is lower than conduction losses when applying SPWM for the two inverters. Conduction losses the dominant losses of power switches are the conduction losses. For simplicity, the switching losses are neglected. The conduction losses of each switch and its freewheeling diode is considered.

II) Leakage current

Leakage current flows from the PV panel to the ground through a parasitic capacitance whose value is set at 60 nF for each case. The PV leakage current with the two inverters and when applying the two techniques of switching the inverters. All values of leakage currents are within the limit according to standard (VDE 0126 - 1 - 1 - 2006, 2008). The leakage current in case of HERIC inverters is lower than that when applying H5 inverter.

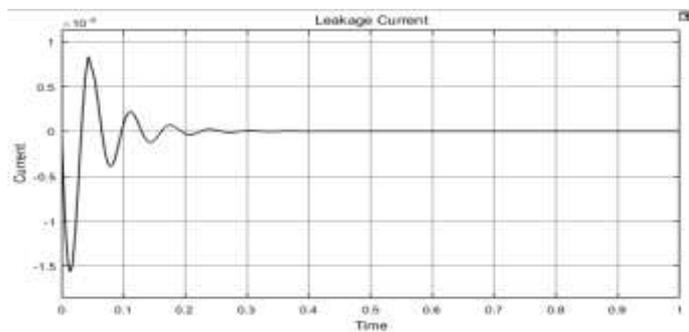


Fig.3. Leakage current of HERIC topology.

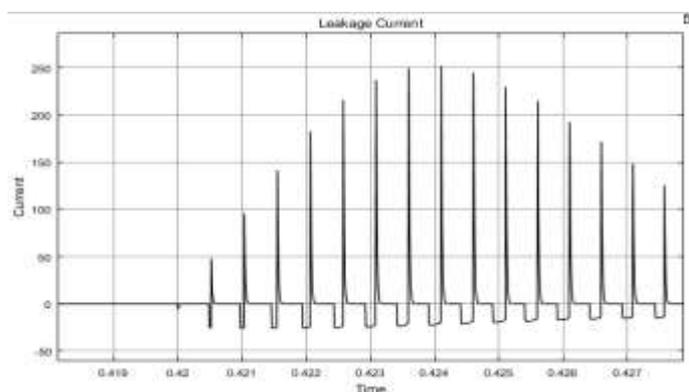


Fig.4. Leakage current of H5 topology.

III) LCL filter size

A simple LCL filter is utilized to cancel the harmonics in the output voltage of the inverters. The values of filter capacitance are very close in all cases while the inductance value using SHE technique is nearly three times that in SPWM. The reason is that using SHE technique only eliminates selected low order harmonics.

Table 1 LCL filter size of each inverter

Inverter type	Capacitance (μF)	Inductance (mH)
HERIC (SPWM)	40	12
HERIC (SHE)	35	35
H5 (SPWM)	40	12
H5 (SHE)	35	35

3. RESULT

The outcomes demonstrate that the proposed topology with the galvanic isolation technique alone can't totally dispose of leakage current. Then again, the common mode voltage is totally clamped at 400 V during the whole time frame, and a total end of leakage current is accomplished with the modified proposed topology. In addition, there is present distortion in the negative power district with conventional PWM, while with the proposed regulation, a current path is made and the current distortion is dispensed with. Besides, THD is decreased by 82% with the modified modulation technique. The proficiency of the framework is estimated with SiC MOSFET to upgrade framework execution, particularly with reactive power generation. It is seen that framework proficiency diminished by 2% at 100 kHz because of the reactive power ability, because the increase in conducting switches also increases loss. In brief, the proposed modulation technique satisfies the requirement for a next-generation, single-phase, PV grid tied inverter where reactive power control is required.

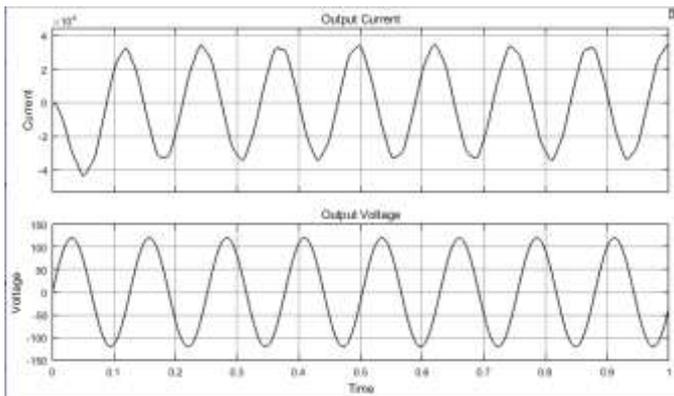


Fig.5. Output of HERIC topology inverter.

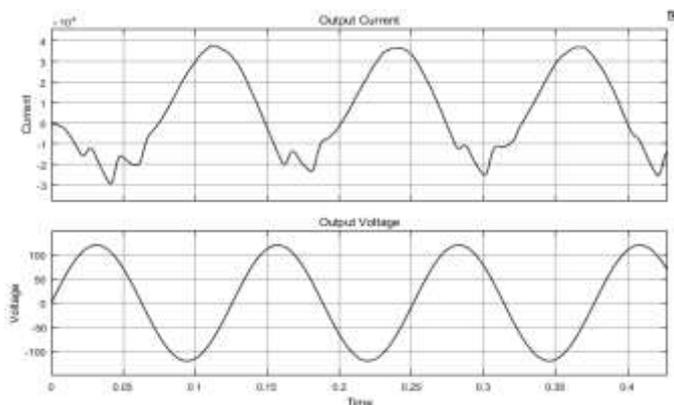


Fig 6. Output of H5 topology inverter.

4. CONCLUSION

When working at high exchanging recurrence, the stray capacitors will be charged and released by the common mode voltage (CMV). As a result, a resonant circuit is formed that includes PV stray capacitors, grid impedance and output filter inductances. Consequently, the resonant circuit will be energized and the leakage current will move through the parasitic capacitances between the PV panel and the ground. There are numerous detriments related with the circling of leakage current in the framework, for example, expanded framework misfortunes, total harmonic distortion (THD) and genuine security and radiated interference problems issues. In this paper, a proposed topology is changed with an additional change to accomplish constant common mode voltage and eliminating leakage current. Besides, the modulation method is modified with the goal that reactive power generation can be accomplished. Three voltages' states must be created in the negative power region to fulfill the necessity of unipolar PWM. In any case, regular unipolar PWM can't produce a zero-voltage in the negative power region. The proposed modulation technique makes another present way in the negative power area where a zero-voltage state can be accomplished. To this end, the proposed modulation technique empowers the proposed

inverter with reactive power generation with no progressions to the inverter structure. Moreover, the proposed modulation achieved a constant common mode voltage that leads to eliminating leakage current.

References

1. Li, W.; Gu, Y.; Luo, H.; Cui, W.; He, X.; Xia, C. Topology review and derivation methodology of single-phase transformerless photovoltaic inverters for leakage current suppression. *IEEE Trans. Ind. Electron.* 2015, 62, 4537–4551
2. Guo, X.; He, R.; Jian, J.; Lu, Z.; Sun, X.; Guerrero, M. Leakage current elimination of four-leg inverter for transformerless three-phase PV systems. *IEEE Trans. Power Electron.* 2016, 31, 1841–1846.
3. Kerekes, T.; Teodorescu, R.; Rodríguez, P.; Vázquez, G.; Aldabas, E. A new high-efficiency single-phase transformerless PV inverter topology. *IEEE Trans. Ind. Electron.* 2011, 58, 184–191.
4. Dutta, S.; Debnath, D.; Chatterjee, K. A grid-connected single-phase transformerless inverter controlling two solar PV arrays operating under different atmospheric conditions. *IEEE Trans. Ind. Electron.* 2018, 65, 374–385.
5. Knabben, G.C.; Schmitz, L.; Coelho, R.F.; Martins, D.C.; Custódio, O.J.; de Medeiros, R.Z.; Bettiol, A.L. Transformerless micro-inverter for grid-connected photovoltaic systems. In *Proceedings of the 52nd International Universities Power Engineering Conference (UPEC)*, Heraklion, Greece, 28–31 August 2017; pp. 1–6.
6. AZhao, T.; Bhavaraju, V.; Nirantare, P.; Xu, J. Evaluation of commercial scale transformerless solar inverter technology. In *Proceedings of the 2015 IEEE Energy Conversion Congress and Exposition (ECCE)*, Montreal, QC, Canada, 20–24 September 2015; pp. 5342–5348.
7. Chen, B.; Lai, J.S. A family of single-phase transformerless inverters with asymmetric phase-legs. In *Proceedings of the 2015 IEEE Applied Power Electronics Conference and Exposition (APEC)*, Charlotte, NC, USA, 15–19 March 2015; pp. 2200–2205.
8. Lee, J.; Lee, K. New modulation techniques for a leakage current reduction and a neutral-point voltage balance in transformerless photovoltaic systems using a three-level inverter. *IEEE Trans. Power Electron.* 2014, 29, 1720–1732.
9. Freddy, T.; Rahim, N.; Hew, W.; Che, H. Modulation techniques to reduce leakage current in three-phase transformerless H7 photovoltaic inverter. *IEEE Trans. Ind. Electron.* 2015, 62, 322–331.
10. Cha, W.; Kim, K.; Cho, Y.; Lee, S.; Kwon, B. Evaluation and analysis of transformerless photovoltaic inverter topology for efficiency improvement and reduction of leakage current. *IET Power Electron.* 2014, 8, 255–267.