Paper ID: NITETE&TC04

MODIFIED COUPLED-INDUCTOR SINGLE-STAGE BOOST INVERTER BASED GRID-CONNECTED PHOTOVOLTAIC (PV) SYSTEM

Mr.Mohasin Shafiahamad Bijali.
M.E.Electrical 2nd Year,
Fabtech Technical Campus,Sangola.
Solapur University.

Prof. MallaReddy Chinala
H.O.D   Electrical Department,
Fabtech Technical Campus,Sangola.

Prof. Anitha Chirra
Assit.Proff.   Electrical Department,
Fabtech Technical Campus,Sangola.

ABSTRACT

Grid connected Photovoltaic (PV) Power System has been attracting more and more attention for its lower cost, smaller volume, as well as higher efficiency. One of the technical challenges is the safety issue of the leakage current caused by the common mode voltages (CMV) conducting in the loop with parasitic capacitors between the solar panel and the ground. A coupled inductor single stage boost inverter (CL-SSBI) will be introduce an impedance network, including coupled inductor in the front end of inverter bridge. Using coupled inductor single stage boost inverter (CL-SSBI) with near state pulse width modulation (NSPWM) which can reduce leakage current of the grid connected PV system. The proposed transformer less grid connected photovoltaic (PV) system on the CL-SSBI modulated by NSPWM will be simulated in MATLAB/SIMULINK.

INTRODUCTION

The transformer less photovoltaic (PV) power system has been attracting more and more attention for its lower cost, smaller volume, as well as higher efficiency, compared to the ones with transformer. One of the technical challenges is the safety issue of the leakage current caused by the common mode voltages, conducting in the loop with parasitic capacitors between the solar panel and the ground. A coupled inductor single-stage boost inverter (CL-SSBI) is proposed in, which introduced an impedance network, including coupled inductor in the front-end of the inverter bridge. The converter uses shoot-through zero vectors to store and transfer energy within the unique impedance network, to step up the bus voltage. Turns ratio of the coupled inductor within the impedance network can also be designed to improve the boost gain. So the ac output voltage can be regulated in a wide range and can be stepped up to a higher value. Higher power loss and lower efficiency would be unavoidable if higher boost gain is required, which is the disadvantage of a coupled inductor single stage boost inverter. As shoot-through zero vectors evenly distributed among the three phase legs during a switching period, the equivalent switching frequency viewed from the impedance network can be six times the switching frequency of the inverter bridge, which will greatly reduce the power density and cost of the inverter. A diode is added in the front of the topology to block the leakage current loop when in the active vectors and open-zero vectors. In addition, the near-state PWM (NSPWM) technique is used with one-leg shoot-through zero vectors to reduce the leakage current caused in the transient states of changing from and to open-zero vectors. And the leakage current can be reduced effectively without lowering the maximum magnitude of the output reference voltage, for the modulation index of NSPWM stays in the high modulation section.

LITERATURE REVIEW

Below is a literature review of works carried out in last few years for detecting modulation technique for the modified coupled-inductor single-stage boost inverter (CLSSBI) based grid-connected photovoltaic (PV) system.

a)**High efficiency single phase transformerless inverters** by S.V.Araujo and P.Zacharias: This paper talks about the H-Bridge with a new AC bypass circuit consisting in diode rectifier and a switch with clamping to the DC midpoint to acquire higher efficiencies combining with very low ground leakage current.

b)**Transformerless inverter for single phase photovoltaic system** by R.Gonzalez presented at Mar 2007:This paper talks about when no transformer is used in a grid connected photovoltaic(PV) system a

galvanic connection between the grid and PV array exists. In these conditions dangerous leakage currents can appear between PV array and ground. Avoid these leakage current, different inverter topologies that generate no varying common-mode voltages such as half-bridge and the bipolar pulse width modulation full-bridge topologies.

c)Single stage boost inverter with coupled inductor by Y.Zhou and W.Huang:By introducing impedance network, including coupled inductor into the three phase bridge inverter and adjusting the previously forbidden shoot-through zero state,The converter can realize a high boost gain and output a stable ac voltage. As in power systems distributed generation units often experience big changes in the inverter input voltage due to fluctuations of energy sources. Often a front end boost converter is added to step up the dc voltage when energy resources are at a weak point.

d)Grid connected single phase photovoltaic inverters by I.Patro: Need of a high input voltage represents an important drawback of the half bridge, the bipolar PWM full bridge requires a lower input voltage but exhibits a low efficiency.

e)Boost-control methods for the Z-source inverter which can obtain maximum voltage gain at any given modulation index without producing any low-frequency ripple that is related to the output frequency and minimize the voltage stress at the same time. Thus, the Z-network requirement will be independent of the output frequency and determined only by the switching frequency.

f)Eliminating leakage currents in neutral point clamped inverters for photovoltaic system by M. C. Cavalcanti: The main contribution of this paper is the proposal of new modulation techniques for three-phase transformerless neutral point clamped inverters to eliminate leakage currents in photovoltaic systems without requiring any modification on the multilevel inverter or any additional hardware. The modulation techniques are capable of reducing the leakage currents in photovoltaic systems by applying three medium vectors or using only two medium vectors and one specific zero vector to compose the reference vector. In addition, to increase the system utilization, the three-phase neutral point clamped inverter can be designed to also provide functions of active filter using the p-q theory.

g)Grid-connected PV single-phase converter is usually employed. It is possible to adopt converter topologies without galvanic isolation between the photovoltaic (PV) panels and the grid. The absence of a high- or line-frequency transformer permits us to reduce power losses, cost, and size of the converter. On the other side, in the presence of a galvanic connection, a large ground leakage current could arise due to parasitic PV panel capacitance. Leakage currents cause electric safety problems, electromagnetic interference increase and consequently, a reduction of the converter power quality.

PROBLEM STATEMENT
Turns ratio of the coupled inductor within the impedance network can also be designed to improve the boost gain. So the AC output voltage can be regulated in a wide range and can be stepped up to a higher value. Higher power loss and lower efficiency would be unavoidable if higher boost gain is required, which is the disadvantage a coupled inductor single stage boost inverter. As shoot-through zero vectors evenly distributed among the three phase legs during a switching period, because conventional system switching frequency is low. In proposed system the near state pulse width modulation (NSPWM) technique is applied with one-leg shoot-through zero vectors in order to reduce the leakage current through the conduction path in the duration of changing from and to open-zero vectors.

OBJECTIVE & SCOPE
OBJECTIVE:-
The objective of proposed "Modified Coupled Inductor Single stage Boost Inverter Based Grid-connected Photovoltaic (PV) System" is as follows-
   i)   Reduce the leakage current caused by common mode voltages in grid connected photovoltaic (PV) system without lowering the magnitude of reference common mode voltages.
   ii)   Improve the boost gain for the regulation of wide range of output voltage without increasing the power loss and improve the efficiency of the system.

SCOPE OF THE PROJECT-
The Technical challenges is the safety issue of the leakage current caused by common mode voltages (CMV), conducting in the loop with parasitic capacitors between the solar panel and the ground. For single stage boost inverter transformerless PV systems, such as the Z-source inverter based systems, the modulation strategy is carefully designed to maintain the constant CMV to reduce the leakage current. But the OPWM or EPWM method uses only odd or even active vectors to synthesize the output reference voltage, leading to only 57.7% of the maximum magnitude compared to SVPWM, and also to worsen harmonic distortion of the output waveforms.

METHODOLOGY

Below is the modular approach for the proposed project-

I) SYSTEM LEVEL BLOCK DIAGRAM: - First the complete system level block diagram will be designed and evaluated as per the system specifications.

II) EACH BLOCK DESIGN: - Once the block diagram is created, then each block will be design and verified in accordance with their specifications and functionality.

III)BLOCK INTERCONNECTIONS: - The design of individual blocks are connected and form the final circuit design, which will be again verified with system specifications.
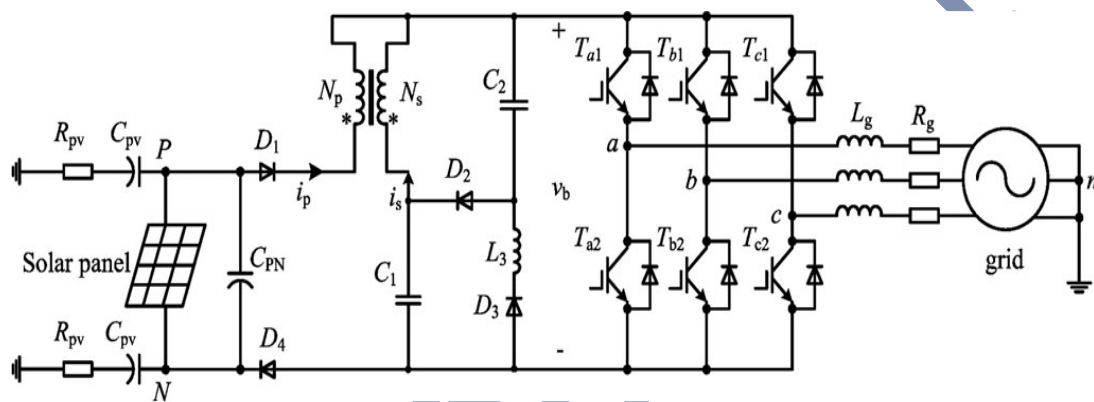
IV) CIRCUIT DIAGRAM:-

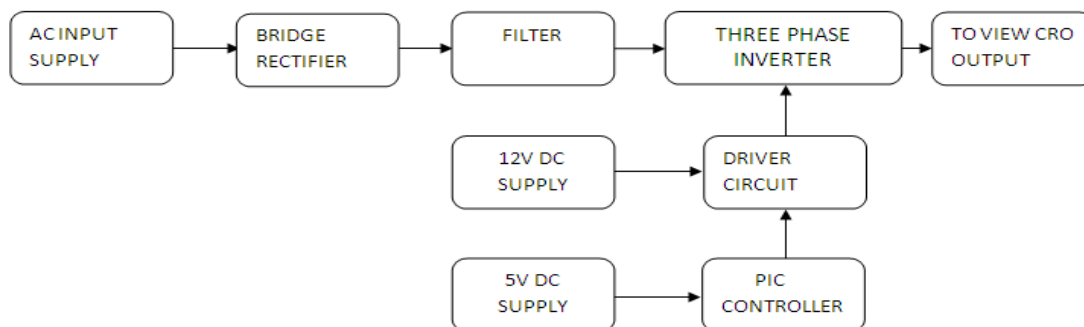**Fig. Circuit Diagram**

V)BLOCK DIAGRAM:-

Fig. Block Diagram

VI)SOFTWARE / FIRMWARE: - Once the connections are tested then the firmware flow diagram for critical path will be design and accordingly the firmware will be written in MATLAB/SIMULINK. Firmware will also be divided in smaller functions, which will be written and tested independently. Once each small functions are tested and verified then it will be integrated in main firmware as per the logic required for the operation of project. A strategy will be formulated to detect the abnormalities in voltage and frequency in power system.

VII) SOFTWARE REQUIREMENTS: MATLAB – SIMULINK

VIII) SIMULATION: In mat lab NSPWM technique is used for generating the gate pulse for the inverter.

CONCLUSION

A transformer less grid-connected PV system based on a coupled inductor single-stage boost three phase inverter. Diode D4 is added in the front of the topology together with D1, to block the leakage current loop during the active vectors and open-zero vectors. The leakage current caused in the transient states of changing

from and to shoot-through zero vectors is also reduced by using the NSPWM technique with one-leg shoot-through zero vectors, when open-zero vectors are omitted. Simultaneously, the leakage current caused by other transitions can be further reduced due to the magnitude reduction of the common mode voltages. The common mode voltages and the caused leakage currents are compared between CL-SSBI with NSPWM. According to the simulation results, the amplitude and RMS value of the leakage current can be well below the threshold level required by the VDE0126-1-1 standards, indicating an effective leakage current reduction.

REFERENCES

[1] R. Gonzalez, J. Lopez, P. Sanchis, and L. Marroyo, "Transformerless inverter for single-phase photovoltaic systems," IEEE Trans. Power Electron., vol. 22, no. 2, pp. 693–697, Mar. 2007.

[2] H. Xiao and S. Xie, "Transformerless split-inductor neutral point clamped three-level PV grid-connected inverter," IEEE Trans. Power Electron., vol. 27, no. 4, pp. 1799–1808, Apr. 2012.

[3] S. V Araujo, P. Zacharias, and R. Mallwitz, "High efficiency single-phase transformerless inverters for grid-connected photovoltaic systems," IEEE Trans. Ind. Electron., vol. 57, no. 9, pp. 3118–3128, Sep. 2010.

[4] M. C. Cavalcanti, K. C. de Oliveira, A. M. de Farias, F. A. S. Neves,G. M. S. Azevedo, and F. Camboim, "Modulation techniques to eliminate leakage currents in transformerless three-phase photovoltaic systems," IEEE Trans. Ind. Electron., vol. 57, no. 4, pp. 1360–1368, Apr. 2010.

[5] J. M. Shen, "Novel transformerless grid-connected power converter with negative grounding for photovoltaic generation system," IEEE Trans Power Electron., vol. 27, no. 4, pp. 1818–1829, Apr. 2012.

[6] O´. Lo´pez, F. D. Freijedo, A. G. Yepes, P. Ferna´ndez-Comesan˜a, J.Malvar,R. Teodorescu, and J. Doval-Gandoy, "Eliminating ground current in a transformerless photovoltaic application," IEEE Trans. Energy Convers.,vol. 25, no. 1, pp. 140–147, Mar. 2010.

[7] F. Bradaschia, M. C. Cavalcanti, P. E. P. Ferraz, F. A. S. Neves, E. C. dos Santos, Jr., and J. H. G. M. da Silva, "Modulation for three-phase transformerless Z-source inverter to reduce leakage currents in photovoltaic systems," IEEE Trans. Ind. Electron., vol. 58, no. 12, pp. 5385–5395,Dec. 2011.

[8] X. Guo, M. C. Cavalcanti, A. M. Farias, and J. M. Guerrero, "Singlecarrier modulation for neutral point-clamped inverters in three-phase transformerless photovoltaic systems," IEEE Trans. Power Electron., vol. 28, no. 6, pp. 2635–2637, Jun. 2013.

[9] I. Patrao, E. Figueres, F. Gonzalez-Espin, and G. Garcera, "Transformerless topologies for grid-connected single-phase photovoltaic inverters," 1046 IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 29, NO. 3, MARCH 2014 Renewable Sustainable Energy Rev., vol. 15, no. 7, pp. 3423–3431, Sep. 2011.

[10] D. Barater, G. Buticchi, A. S. Crinto, G. Franceschini, and E. Lorenzani, "Unipolar PWM strategy for transformerless PV grid-connected converters,"IEEE Trans. Energy Convers., vol. 27, no. 4, pp. 835–843, Dec. 2012.

[11] M. C. Cavalcanti, A. M. Farias, K. C. de Oliveira, F. A. S. Neves, and J. L. Afonso, "Eliminating leakage currents in neutral point clamped inverters for photovoltaic systems," IEEE Trans. Ind. Electron., vol. 59, no. 1, pp. 435–443, Jan. 2012.

[12] T. Salmi, M. Bouzguenda, A. Gastli, and A.Masmoudi, "Transformer less micro inverter for photovoltaic systems," Int. J. Energy Environ., vol. 3, no. 4, pp. 639–650, Jan. 2012.

[13] B. Yang, W. H. Li, Y. J. Gu, W. F. Cui, and X. N. He, "Improved transformer less inverter with common-mode leakage current elimination for a photovoltaic grid-connected power system," IEEE Trans. Power Electron., vol. 27, no. 2, pp. 752–762, Feb. 2012.

[14] B. Gu, J. Dominic, J.-S. Lai, C.-L. Chen, T. LaBella, and B. Chen, "High reliability and efficiency single-phase transformerless inverter for gridconnected photovoltaic systems," IEEE Trans. Power Electron., vol. 28, no. 5, pp. 2235–2245, May 2013.

[15] E. Koutroulis and F. Blaabjerg, "Design optimization of transformerless grid-connected PV inverters including reliability," IEEE Trans. Power Electron., vol. 28, no. 1, pp. 325–335, Jan. 2013.

[16] Y. Zhou and W. Huang, "Single-stage boost inverter with coupled inductor," IEEE Trans. Power Electron., vol. 27, no. 4, pp. 1885–1893, Apr.2012.

[17] F. Z. Peng, "Z-source inverter," IEEE Trans. Ind. Appl., vol. 39, no. 2, pp. 504–510, Mar. 2003.

[18] M. Shen, J. Wang, A. Joseph, F. Z. Peng, L. M. Tolbert, and D. J. Adams, "Constant boost control of the Z-source inverter to minimize current ripple and voltage stress," IEEE Trans. Ind. Appl., vol. 42, no. 3, pp. 770–778, 2006.