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AN OVERVIEW OF 1-PHASE TRANSFORMERLESS HERIC INVERTER TOPOLOGY FOR STANDALONE SYSTEM

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Abstract — *Transformerless inverters are widely used in grid-tiedPhotovoltaic (PV) generation systems, due to the benefits of achieving high efficiency and low cost. To design an efficient solar inverter higher efficiency and also to control the power that the inverter injects into the standalone system [5]. Various transformerless inverter topologies have been proposed to meet the safety requirement of leakage currents, less harmonics. In this paper, HERIC transformerless inverter topologies with low leakage currents is proposed highly efficient and reliable inverter concept topology has been discussed with MATLABsimulation and also discussed about PV, MPPT, SPWM and DC/DC boost Converter with MATLAB Simulation [1]–[3].*

Keywords - *Common-mode voltage, grid-tied inverter, leakageCurrent, photovoltaic (PV) generation system, SPWM, MPPT, Transformerless inverter and MATLAB/Simulink***.**

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. Government can provide subsidies for the production of PV panels, in which there will be reduction in the market price and this can lead to more usage of solar power in India.

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 5 kW). From the safety point of view, most of the PV grid-tied inverters employ line-frequency transformers to provide galvanic isolation in commercial structures in the past. However, line-frequency transformers are large and heavy, making the whole system bulky and hard to install. Compared with line-frequency isolation, inverters with high-frequency isolation transformers have lower cost, smaller size and weight. However, the inverters with high-frequency transformers have several power stages, which increase the system complexity and reduce the system efficiency [1]–[6]. As a result, the transformerless PV grid-tied inverters are widely installed in the low-power distributed PV generation systems.

Unfortunately, when the transformer is removed, the common mode (CM) leakage currents (*l*eakage) may appear in the system and flow through the parasitic capacitances between the PV panels and the ground [7], [8]. Moreover, the leakage currents lead to serious safety and radiated interference issues [3]. Therefore, they must be limited within a reasonable range.

II. PHOTOVOTAIC SYSTEM

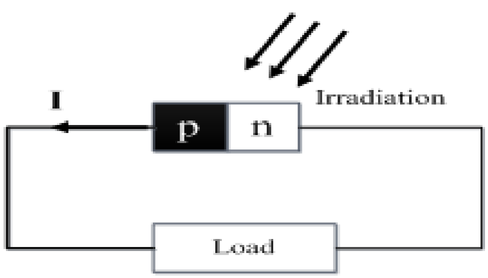

Figure 1. Solar cell

The output of one crystalline silicon photovoltaic cell is approximately 0.5V. In order to produce a specific output voltage solar cells are connected in series. They are electrically connected and mechanically mounted in a frame to form a panel. When panels are wired in series or parallel the form an array. The solar panels are also equipped with necessary protective devices, such as bypass and blocking diodes in order to protect cells from the temperature rise under shady condition or to prevent it from reverse current owing back during night [10].

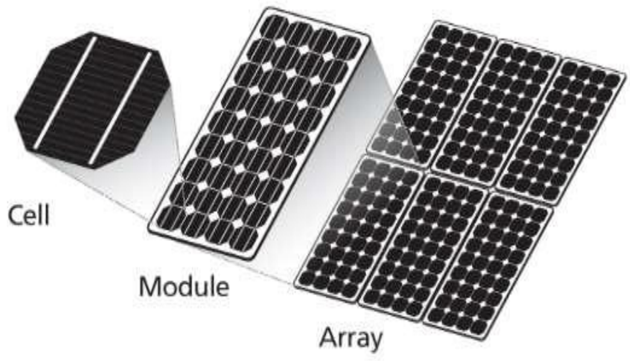

Figure 2. PV Array

Photovoltaic cells uses the "photovoltaic effect" phenomenon to produce the electricity. The physics of PV cell is similar to conventional PN junction diode. Whenever the light falls on the junction, the energy of it is transferred to the electron-hole pair, thus the free charge carriers are generated. These charge carriers creates the potential gradient and gets accelerated under the electric field. This will cause the current to flow through the external circuit [10].

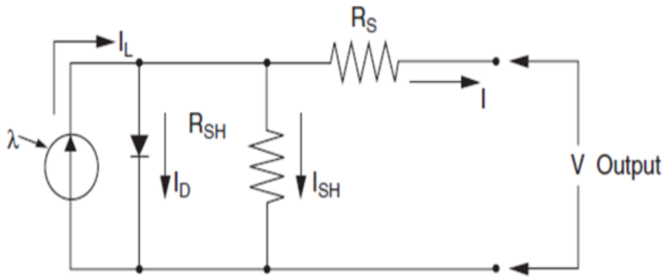

Figure 3. Basic Model of Solar cell

III. DC-DC BOOST CONVERTER

Generally the output of PV panel is very low and it changes according to the atmospheric condition. So in order to make DC link voltage Vdc constant irrespective of the change in input from PV panel an additional stage is used i.e. Boost converter is used to boost up the voltage at a constant level irrespective of the change in input. Fig. below shows thecircuit diagram of boost converter. A proper design and selection of each component is done [6].

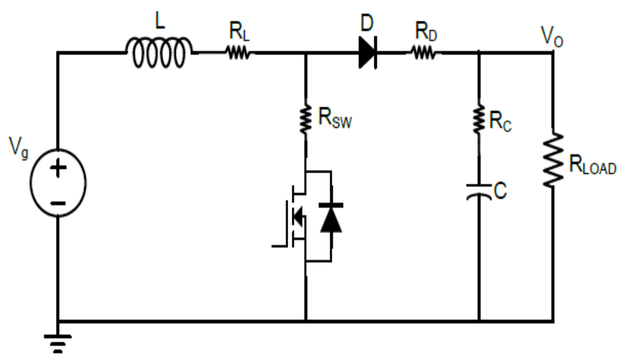

Figure 4. Circuit Diagram of Boost Converter

A boost type DC to DC converter steps up the input voltage level using a circuit made with two switches (MOSFET and diode), an inductor and a capacitor as shown in Figure 4.

In ON state, the switch is on and the source pumps energy into the inductor. Diode is reverse biased during this interval.

In OFF state, the switch is off. As the inductor current must have a path, the diode is forward biased to release the energy stored in the inductor into the load. Relationship between the source and load voltages can be given by the following equation.

$$\frac{v_0}{v_i} = \frac{1}{1-d}$$

The ratio Vo/Vi is the voltage gain of the converter and as per the definition of duty cycle is given by the following equation

$$d = \frac{T_{ON}}{T_{ON} + T_{OFF}}$$

3.1Simulation of DC to DC Boost Converter

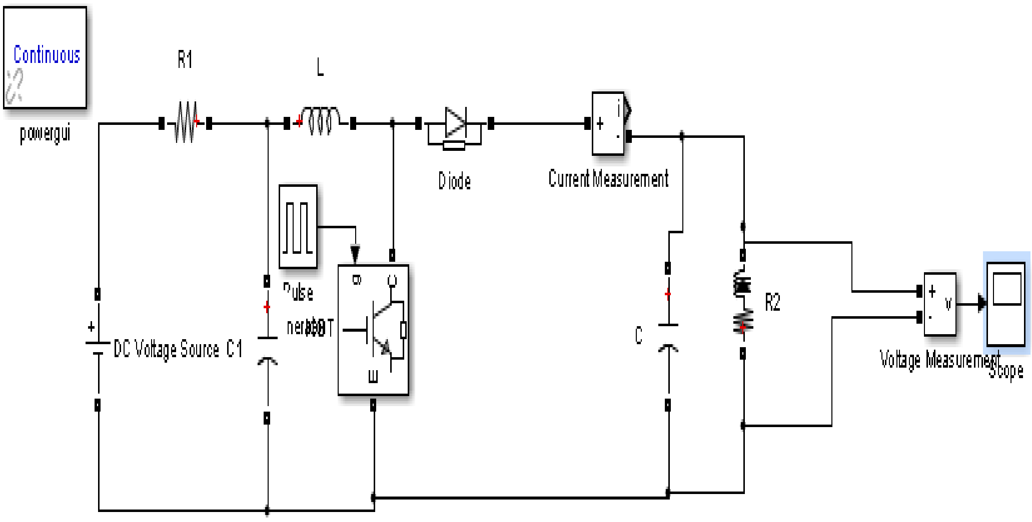

Figure 5. Simulation of DC-DC Converter

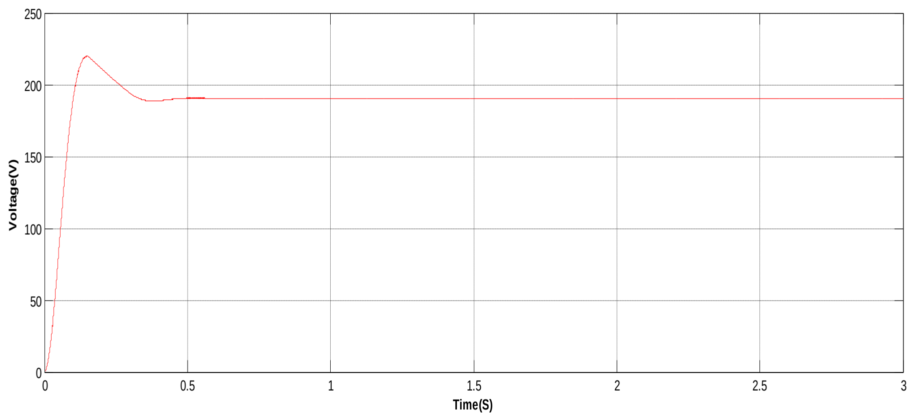

Figure 6. Output Result of DC-DC Converter

IV. MAXIMUM POWER POINT TRACKING SYSTEM (MPPT)

MPPT Calculations are essential on the grounds that the PV arrays have a non-linear V-I Characteristics with a special point where the power produced is maximum. This point basically depends upon the two factors that is irradiance and temperature of the panel. Both these factors changes according to climatic condition and also depends upon the seasons in a year. Moreover, irradiance can change quickly because of evolving climate conditions, for example, mists.

Hence it is imperative to track the MPP precisely during deferent climatic condition with a specific end goal to obtain maximum power. In the late years numerous MPPT calculations have been distributed. They dire in numerous prospective, for example, intricacy, expense, sensors required. However, it is worthless to use a more expensive and complicated method if the same results are obtained from the simpler and less expensive one. This is the reason why some of the proposed techniques are not used. Some of the methods are discussed below. [9]

4.1Perturb and Observe

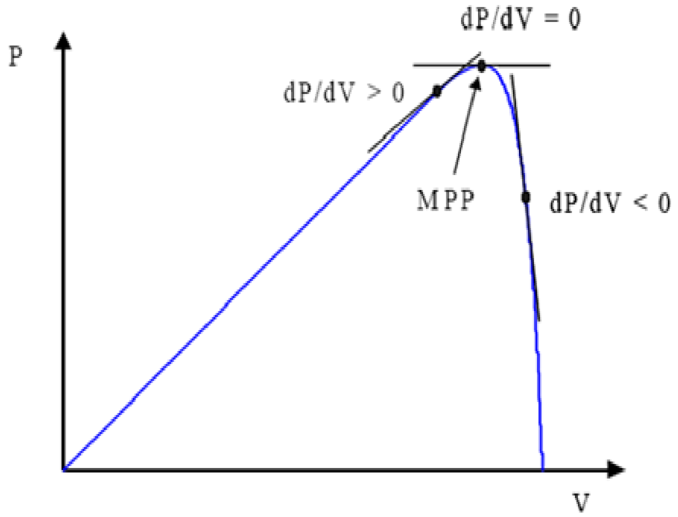

Figure 7. MPPT PV Curve

The Perturb and observe (P&O) algorithm is one of the most used algorithms due to its simplicity and easy implementation. This MPPT method is also known as the Hill Climbing (HC) algorithm. The difference between P& O and HC may be explained by the fact that the HC requires a change in the converter duty cycle, while the P& O perturbs the operating voltage of the PV panel.

Table1.PV Curve Mode Operation

Case	Perturbation dV	Change In Power dP	Next Perturbation (Action)
1	dv>0	dp>0	Positive
2	dv>0	dp<0	Negative
3	dv<0	dp>0	Negative
4	dv<0	dp<0	Positive

The details of P& O algorithm can be understood according to the flowchart displayed in Figure: According to the P& O algorithm, the power is calculated consecutively at previous and current states with the help of voltage and current measurements.
A test is then undertaken to assess the level of variation of power and voltage at consecutive perturbing cycles. If the power and voltage difference is positive, the algorithm increases the operating voltage, if not, it decreases the voltage. Conversely, if the power and voltage difference is negative, the algorithm increases the voltage; if not, it decreases the operating voltage.[9]
The Benefits of P&O Method it is simple, easy to implement, cheap, effective when the insolation changes slowly over time, requiring only panel voltage and current measurements.

V. TRIGGERING TECHNIQUE FOR HERIC INVERTERTOPOLOGY: SPWM

The gating signal generated by sinusoidal reference signal with triangular carrier wave of frequency fc. This sinusoidal modulation is commonly used in industrial application. The frequency of reference fr signal is determine the inverter output frequency fo and its peak amplitude Ar controls the modulation index M and turns the RMS output voltage Vo. comparing the bidirectional carrier signal Vcr with two sinusoidal reference signal vr and –vr. [7]

The output voltage is Vo= V1 (g1- g4)

5.1 Simulation of SPWM Technique

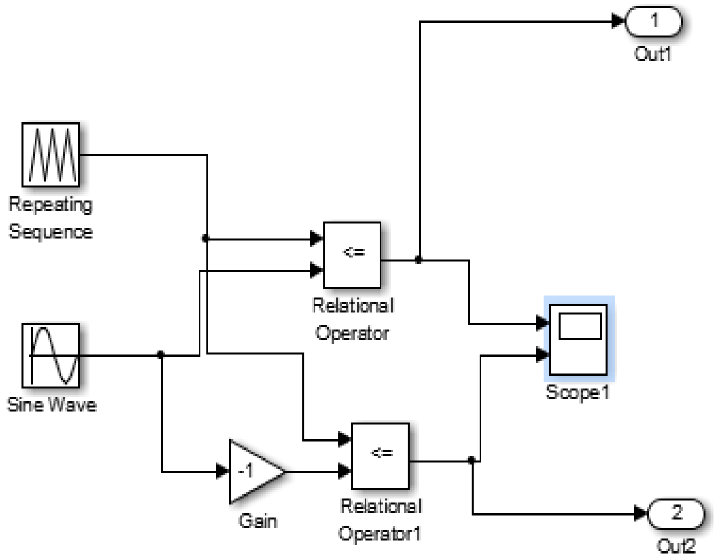

Figure 8. Simulation of SPWM Technique

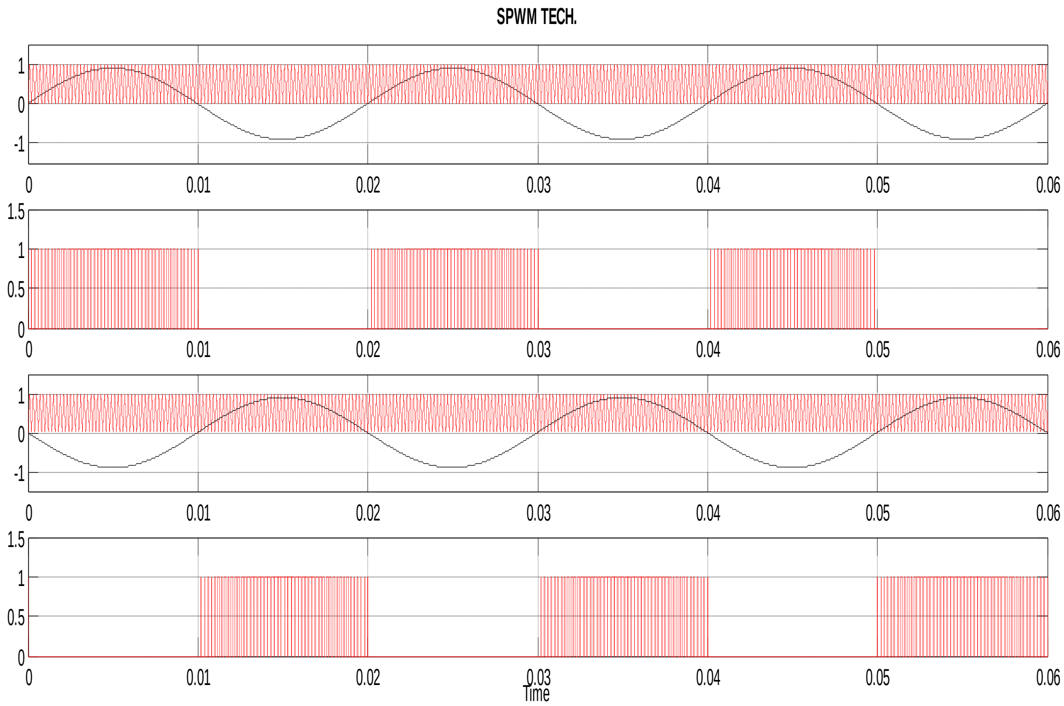

Figure 9. Output Result of SPWM Technique

VI. INVERTER TOPOLOGY

6.1 With Galvanic Isolation

Although there are numerous advantages of two stage but there are some drawbacks of it such as: As the number of stage increases power losses increases and thus Efficiency decreases, it also increases system complexity and hence reliability reduces. These drawbacks can be overcome by the Single stage topology in which the system relies only on inverter [5].

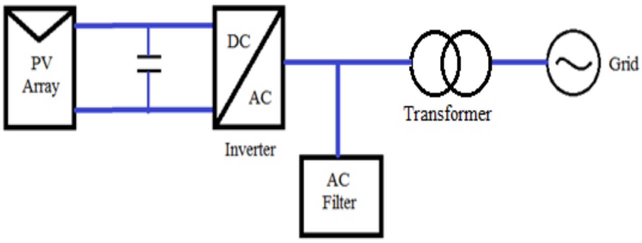

Figure 10. Topology with Galvanic Isolation

6.2 Without Galvanic Isolation

Generally the output from the PV panel is very low and varying with the environmental conditions. Hence a voltage booster is required whose output remains constant irrespective of the input. Thus this topology requires an additional DC-DC converter as shown in fig.11

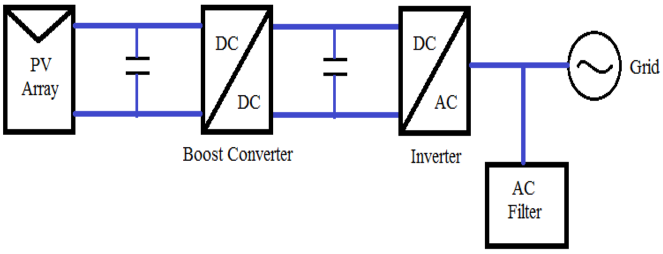

Figure 11. Topology without Galvanic Isolation

6.3 HERIC Inverter

The HERIC topology shown in Figure 12. The HERIC inverter where Cdc is DC-link capacitor, L1 and L2 are filter inductance at grid side and C0 is the filter capacitor. HERIC Employs two extra switches on the ac side of inverter .These additional switches have the two major functions: isolating the photovoltaic panel from the grid, and preventing the reactive power exchange between the filter inductors and capacitors during the zero voltage state, thus increasing efficiency. Also the leakage current path is cut off as well.

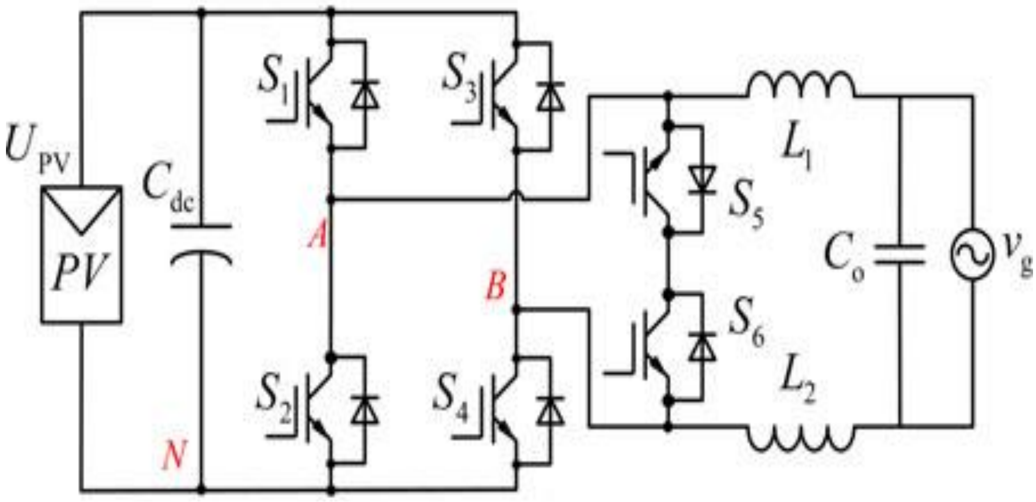

Figure 12. HERIC Topology

6.3.1 Conduction Mode of HERIC Inverter Topology

There are four operation modes. Figure Shows that, in mode (1) S1, S4 Switches conduct. In Mode (2) S5, S6 Switches conduct. Same as in Mode (3) S2, S3 Switches conduct and in Mode (4) S5, S6 Switches conduct.

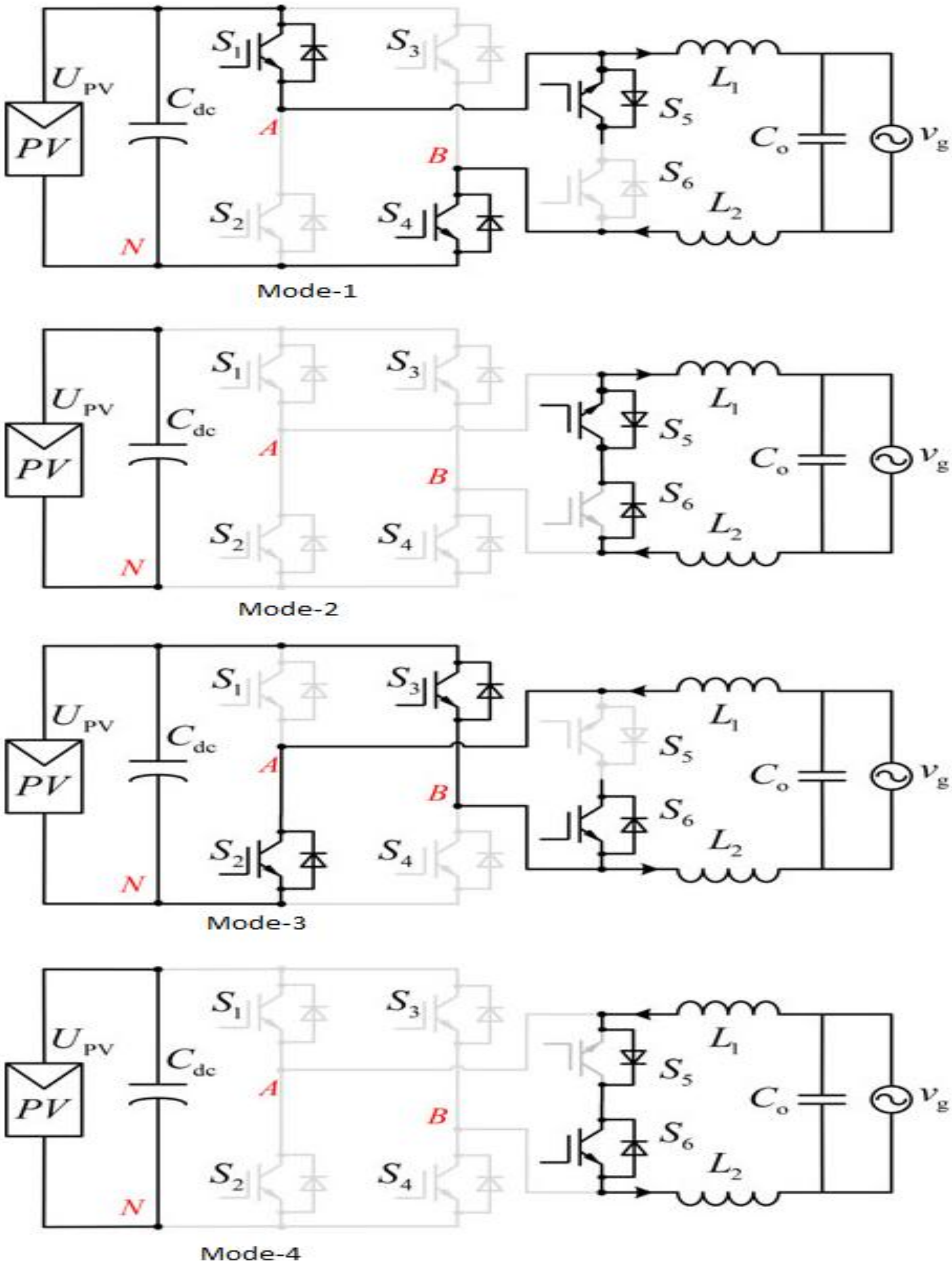

Figure 13. Conduction Modes of HERIC Topology

Table 2.Conduction Mode Operation of HERIC Topology

Mode	Half Period	Conducting Devices
Active	Positive	S1,S4,S5
Free wheeling	Positive	S5,D6
Active	Negative	S2,S3,S6
Free wheeling	Negative	D5,S6

6.3.2 Simulation of HERIC Inverter Topology

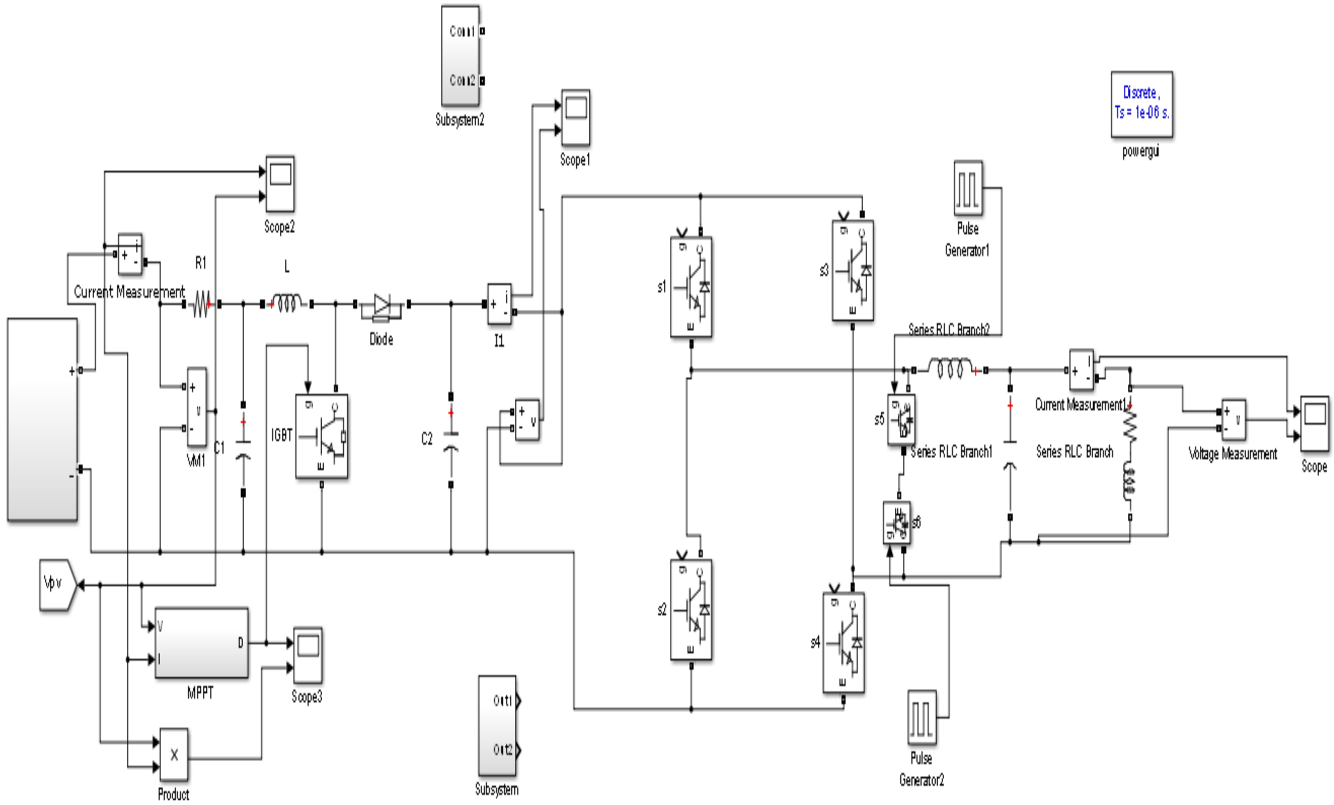

Figure 14. Simulation of HERIC Topology

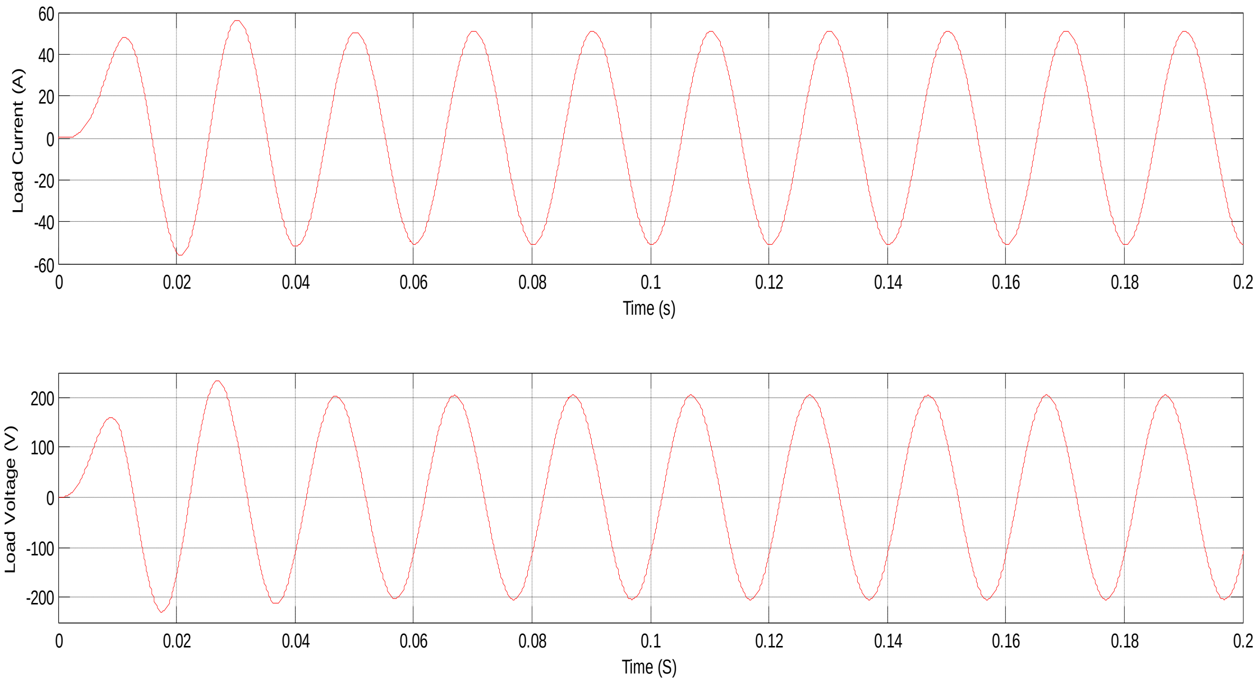

Figure 15. Output Result of HERIC Topology

VII. CONCLUSION

A novel single-phase transformerless grid-connected PV Inverter, which generates no ground leakage current, is proposed in this paper. The efficiency of the proposed HERIC Inverters high. Finally, the simulated results both verify the theoretical analysis.

VIII. REFERENCES

[1]. I Zhang,Member, IEEE, Kai Sun, Member, IEEE, Yan Xing, Member, IEEE, And Mu Xing,"**H6 Transformer Less Full-Bridge PV Grid-Tied Inverters**", IEEE [1]

[2]. Tames Ker Ekes, Remus Teodorescu, Pedro Rodriguez, Gerardo Vazquez, Emiliano, "**A New High- Efficiency Single –Phase Transformer Less PV Inverter Topology**", IEEE (JAN 2011) [2]

[3]. W. Cui, B. Yang, Y. Zhao, W. Li, And X. He, **"A Novel Single-Phase Transformer less Grid-Connected Inverter**," In *Proc. IEEE IECON*, 2011, Pp. 1067–1071

[4]. W. Yu, J. Lai, H. Qi an, and C. Hutchens, "**High-Efficiency MOSFET Inverter with H6-Type Configuration for Photovoltaic Nonisolated Ac-Module Applications**," *IEEE Trans. Power Electron.* Vol. 26, No. 4, Pp. 1253–1260, Apr. 2011 [4]

[5]. 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. [5]

[6]. S. V. Araujo, P. Zacharias, And R. Mallwitz, "**Highly Efficient Single-Phase Transformerless Inverters For Grid-Connected Photovoltaic Systems**," IEEE Trans. Ind. Electron., Vol. 57, No. 9, Pp. 3118–3128, Sep. 2010. [6]

[7]. Rajesh Singh Farswan and B.G. Fernandez, IIT Bombay, "**Low Cost High Reliable Hybrid Switch Single Phase Grid-Tied Inverter**"*IEEE Trans.* 2014. [7]

[8]. Budi YantoHusodo, Shahrin Md. Ayob, MakbulAnwari, Taufik, "**Simulation Of Modified Simple Boost Control For Z-Source Inverter**" International Journal Of Automation And Power Engineering (IJAPE) Volume 2 Issue 4, May 2013. [8]

[9]. Xin Wang, SubbarayaYuvarajan, "**MPPT Control For a Pmsg-Based Grid-Tied Wind Generation System**" IEEE. [9]

[10]. HabbatiBellia, RamdaniYoucef, Moulay Fatima, "**A Detailed Modeling Of Photovoltaic Module Using Matlab**" Nriag Journal of Astronomy and Geophysics, Vol. 3, Issue 1, June 2014. [10]