TO ELIMINATE COMMON MODE LEAKAGE CURRENT IN PHOTOVOLTAIC GRID CONNECTED POWER SYSTEM

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Abstract— To eliminate the common-mode leakage current in the transformer less photovoltaic grid-connected system, an improved single-phase inverter topology is presented. The improved transformer less inverter can sustain the same low input voltage as the full-bridge inverter and guarantee to completely meet the condition of eliminating common-mode leakage current. Both the unipolar sinusoidal pulse width modulation (SPWM) as well as the double frequency SPWM control strategy can be applied to implement the three-level output in the presented inverter. The high efficiency and convenient thermal design are achieved thanks to the decoupling of two additional switches connected to the dc side. Moreover, the higher frequency and lower current ripples are obtained by adopting the double-frequency SPWM, and thus the total harmonic distortion of the grid-connected current are reduced greatly. Furthermore, the influence of the phase shift between the output voltage and current, and the influence of the junction capacitances of the power switches are analyzed in detail. Finally, a 1-kW prototype has been simulated and tested to verify the theoretical analysis of this paper.
Index Terms— Common-mode leakage current, junction capacitance, phase shift, photovoltaic (PV) system, sinusoidal pulse width modulation (SPWM) strategy, transformerless inverter

1. INTRODUCTION:

Now-a-days, the gird-connected photovoltaic (PV) systems, especially the low-power single-phase systems, call for high efficiency, small size, and light weighted and economical grid-connected inverters. Most of the commercial PV inverters make use of either line-frequency or high-frequency isolation transformers. But as we known, line-frequency transformers are large and heavy, which makes system large and unwieldy to install. Topologies with high-frequency transformers commonly include several power stages, makes the system complexity and reduces the system efficiency. As a result, the transformer-less configuration for PV systems is developed to offer the advantages of high efficiency, high power density, and economical. Dismally, there are some safety issues because a galvanic connection between the grid and the PV array exists in the transformer-less systems. A common-mode leakage current flows through the parasitic capacitor between the PV array and the ground once a variable common-mode voltage is generated in transformer-less grid-connected inverters. The common-mode leakage current increases the system losses, thereby decreasing the grid-connected current quality, induces the caustic conducted and radiated electromagnetic interference, and causes personal safety problems. To avoid the common-mode leakage current, the accustomed or common solution employs the half-bridge inverter common-mode voltage is generated. However, the half-bridge inverter requires a high input voltage which is greater than, approximately, 680V for 210-Vac applications. Hence, either larger or the full-bridge inverter with bipolar sinusoidal pulse-width modulation (SPWM), because no variablee numbers of PV modules in series are involved or a boost dc/dc

converter with extremely high-voltage conversion ratio is required as the first power concoct staged. The full-bridge inverter just needs half of the input voltage demanded by the half-bridge topology, which is about 325V for 210-Vac applications. But the main deficiency is that the full-bridge inverter can only employ the bipolar SPWM strategy with two levels, which actuate high current ripple, large filter inductor, as well as low system efficiency. Additional additionally the half-bridge neutral point clamp (NPC) inverter is applied to achieve more level output. However, NPC inverter also demands high input voltage the half-bridge inverter does. Therefore, many advanced inverter topologies for transformer-less PV applications were developed such as H5 inverter, HERIC inverter, etc., as shown in Fig: 1.1. These topologies need the same low input voltage as the full-bridge inverter and can adopt the unipolar SPWM strategy with three levels. The conclusion Drawn from is that various solutions are being researched and employed in transformer-less inverters to minimize the common-mode leakage current and improve the efficiency, g factor, and extent of the whole PV grid-connected power system. In this paper, an ameliorated grid-connected inverter topology for transformer-less PV systems is presented, which can sustain the same low input voltage as the full-bridge inverter and guarantee not to generate the common-mode leakage current. Furthermore, both the unipolar SPWM and the double-frequency SPWM with three-level output can be applied in the present inverter. The high efficiency and thermal design are achieved by adopting the unipolar SPWM. Moreover, the higher equivalent frequency and lower current ripples are obtained by using the double-frequency SPWM. Therefore, a smaller filter inductor can be employed and the harmonic contents and total harmonic distortion (THD) of the output current are decreased to the extent, and the grid-connected system power quality is improved accordingly.
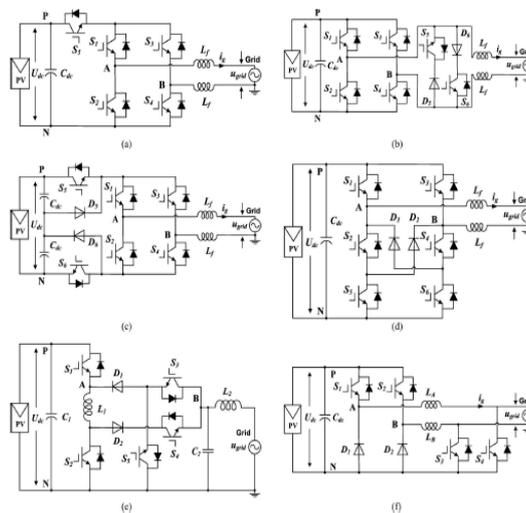

Figure: 1.1 advanced inverter topologies

This paper is systematized as follows. The condition of eliminating common-mode leakage current is analysed in Section II. The improved inverter cartography and correlative operation modes under two SPWM control strategies are introduced in Section III. The ascendancy of the power switches' junction capacitances is illustrated in Section IV. The assumed and pilot results are shown in Section V to analyse the performance of the existing Inverter. Section VI explains the conclusions drawn from the investigation.

2. Voltage Source Inverters:

The main objective of static power converters is to produce an AC output waveform from a dc power supply. These are the different biazons of waveforms required in adjustable speed drives (ASDs), uninterruptible power supplies (UPS), static var compensators, active filters, flexible ac transmission systems (FACTS), and voltage compensators, which are only a few applications. The frequency phase, magnitude of an AC op should be governable. According to the type of ac output waveform, these cartography can be given due consideration as voltage source inverters (VSIs), where the independently controlled and or the full-bridge inverter with bipolar sinusoidal pulse-width modulation (SPWM), because no variable output is a voltage waveform. These Anatomy's are the most widely used because they naturally behave as voltage sources as required by many industrial applications, such as adjustable speed drives (ASDs), which are the most popular application of inverters. likewise, these cartography can be found as current source inverters (CSIs), where the independently controlled ac output is a current waveform. For instance, the ac output voltage produced by the VSI of a standard ASD is a three-level waveform (Fig.2.1c). Although this waveform is not sinusoidal as expected (Fig.2.1b), its fundamental component behaves as such. The modulating techniques most used are the carrier-based technique (e.g., sinusoidal pulse width modulation, SPWM), the space-vector (SV) technique, and the selective-harmonic-elimination (SHE) technique.
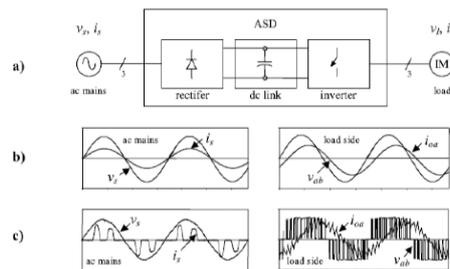

Fig.2. 1: The ac output voltage produced by the VSI of a standard ASD, a) the electrical power conversion apology; b) The ideal input (ac mains) and output (load) waveforms; and c) The actual input (ac mains) and output (load) waveforms.

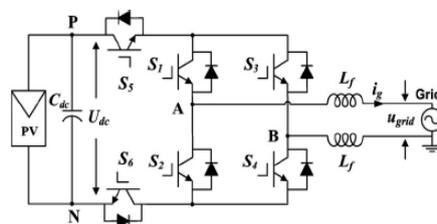## 3. Improved inverter topology and operation modes:

Fig.3.1. Improved inverter topology

Fig. 3.1 shows the improved grid-connected inverter cartography, which can meet the condition of eliminating common-mode leakage current. In this cartography, two additional switches $S5$ and $S6$ are symmetrically added to the conventional full-bridge inverter, and the unipolar SPWM and double-frequency SPWM strategies with three-level output can be achieved.

4. SIMULATION RESULTS:

4.1 Simulated diagram of junction capacitance:
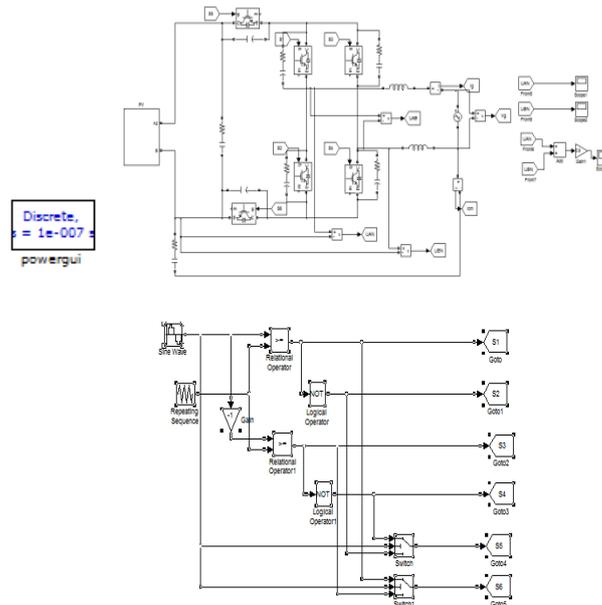

Fig:- 4.1 Designed circuit of simulated results by employing uni-polar SPWM when junction capacitance of six switches are equal.
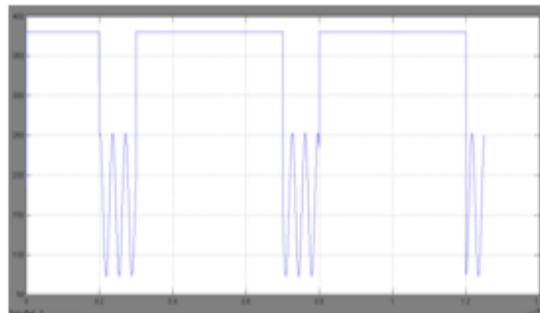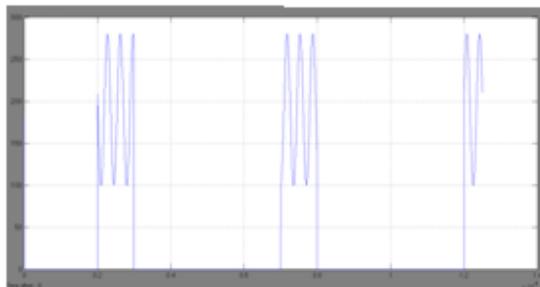

Fig.4.1(a) simulated waveform of uAN
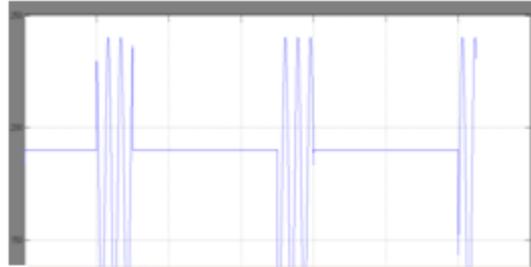

Fig.4.1 (b) simulated waveform of uBN

Fig.4.1 (c) simulated waveform of ucm
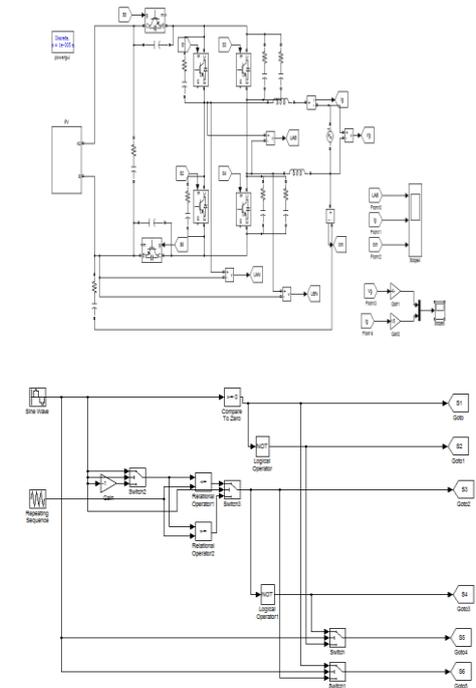
4.2 Simulated diagram of uni-polar SPWM:

Fig.4.2 Designed circuit of Stimulated waveforms of uni-polar SPWM when two additional capacitors with values of 29pf are separately parallel to S3 and S4
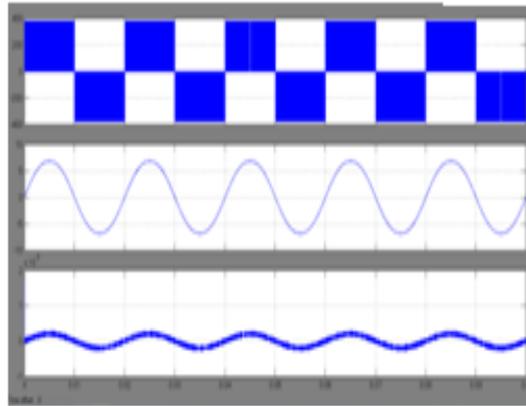
Fig.4.2 (a) simulated waveform of uAB,ig,icm
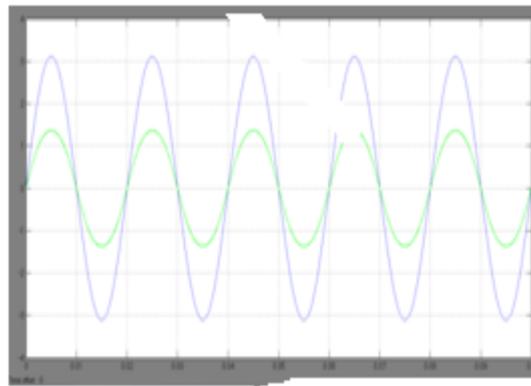
Fig.4.2(b) Simulated waveform of u grid and ig

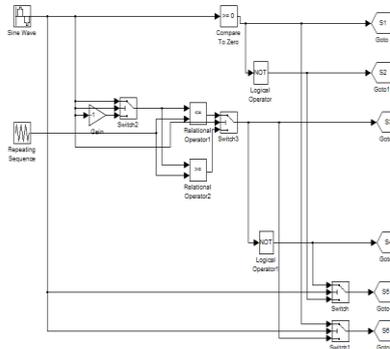## 4.3 Simulated diagram of uni-polar spwm(voltage and current)
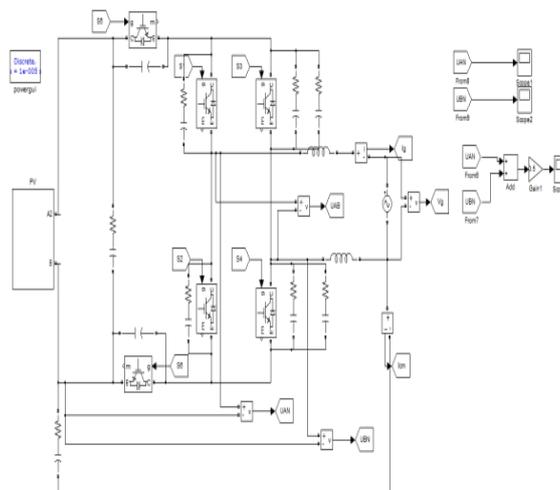
Fig.4.3 Designed circuit of simulated waveforms of uAN,uBN,ucm
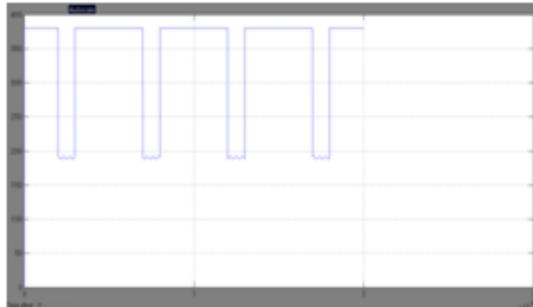

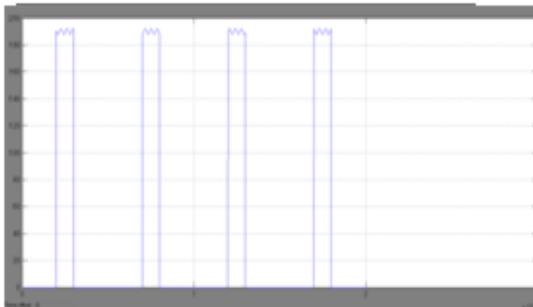Fig.4.4(a) Simulated waveform of uAN

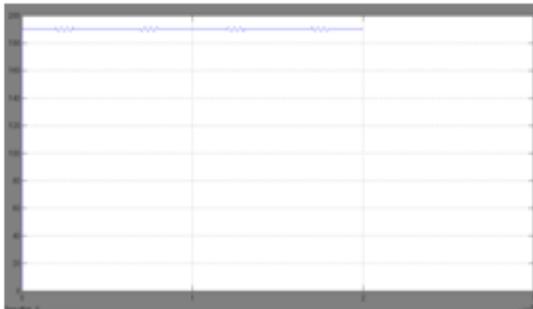Fig.4.3(b) Simulated waveform of uBN

Fig.4.3(c) Simulated waveform of ucm

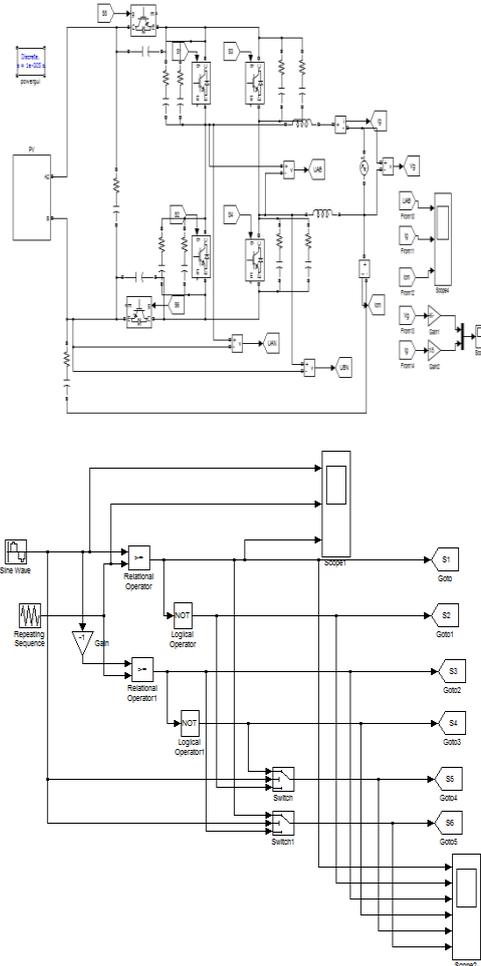**4.4 Simulated diagram of double frequency spwm:**

Fig. 4.4 designed circuit of simulated double frequency spwm with four additional capacitor with values of 470pf respectively parallel to S1 to S4
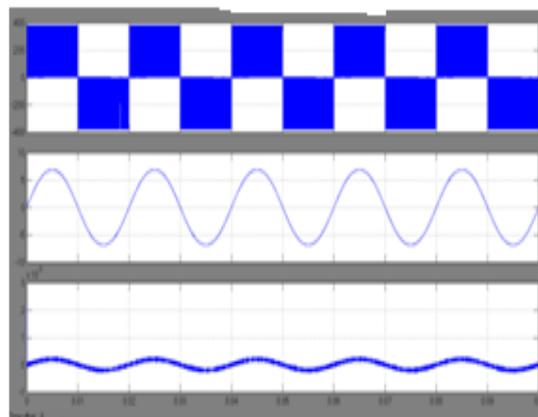

Fig.4.4(a) simulated waveforms of uAB,ig,icm
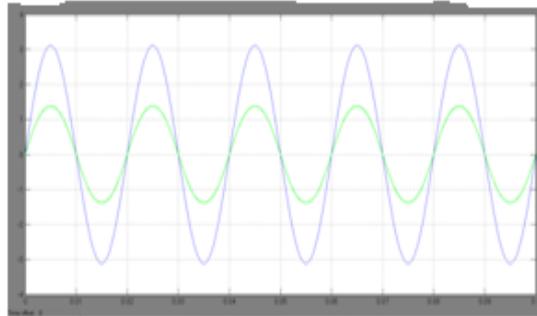
Fig :-4.4(b) simulated waveform of u grid and ig

4.5 simulated diagram of double frequency (voltage and current)
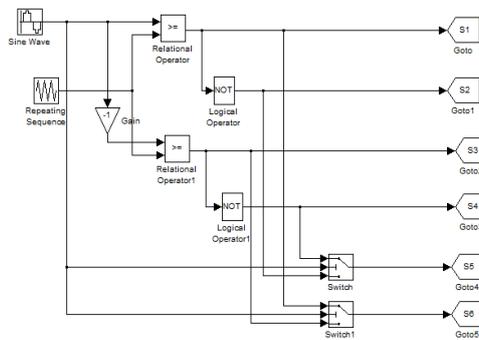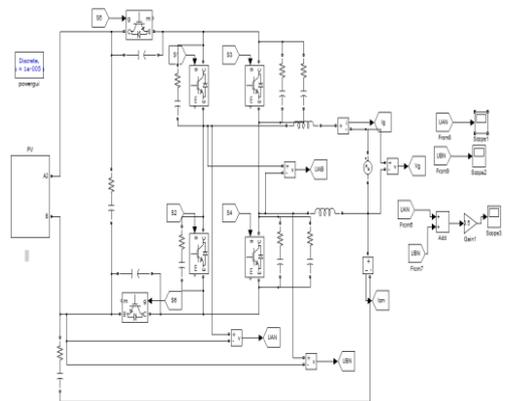

Fig.4.5 Designed circuit of simulated double frequency spwm

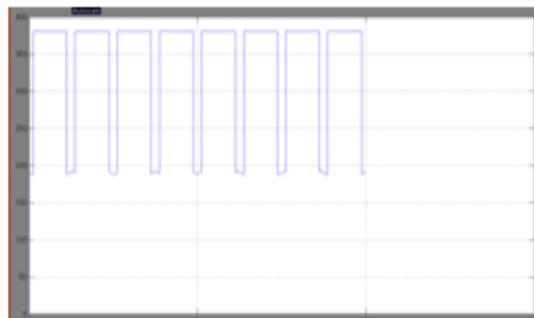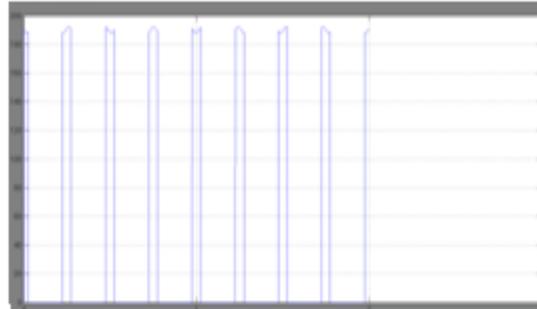Fig .4.5(a)simulated waveform of uAB

Fig.4.5(b) simulated waveform of Ig

Fig. 4.5(c) simulated waveform of icm

5. CONCLUSION:

This paper presented an improved grid-connected inverter topology for transformer-less PV systems. The uni-polar SPWM and double-frequency SPWM control strategies are both implemented with three-level output in the presented inverter, which can guarantee not to generate the common-mode leakage current because the condition of eliminating common-mode leakage current is met completely. Furthermore, the switching voltages of all commutating switches are half of the input dc voltage and the switching losses are reduced greatly. The high efficiency and convenient thermal design are achieved thanks to the decoupling of two additional switches $S5$ and $S6$ .Moreover, by adopting the double-frequency SPWM, the higher frequency and lower current ripples are achieved. Consequently, the higher quality and lower THD of the grid-connected current are obtained, or the smaller filter inductors are employed and the copper losses and core losses are reduced accordingly.

REFERENCES
[1] S. B. Kjaer, J. K. Pedersen, and F. Blaabjerg, "A review of single-phase grid-connected inverters for photovoltaic modules," *IEEE Trans. Ind. Appl.*, vol. 41, no. 5, pp. 1292–1306, Sep./Oct. 2005.
[2] Q. Li and P.Wolfs, "A review of the single phase photovoltaic module integrated converter topologies with three different DC link configurations," *IEEE Trans. Power Electron.*, vol. 23, no. 3, pp. 1320–1333, May 2008.
[3] M. Calais, J.Myrzik, T. Spooner, and V. G. Agelidis, "Inverters for singlephase grid connected photovoltaic systems: An overview," in *Proc. IEEE 33rd Annu. Power Electron. Spec. Conf.*, 2002, vol. 4, pp. 1995–2000.
[4] Z. Yao, L. Xiao, and Y. Yan, "Seamless transfer of single-phase gridinteractive inverters between grid-connected and stand-alone modes," *IEEE Trans. Power Electron.*, vol. 25, no. 6, pp. 1597–1603, Jun. 2010.

[5] B. Yang, W. Li, Y. Zhao, and X. He, "Design and analysis of a gridconnected photovoltaic power system," *IEEE Trans. Power Electron.*, vol. 25, no. 4, pp. 992–1000, Apr. 2010.

[6] J. M. A. Myrzik and M. Calais, "String and module integrated inverters for single-phase grid connected photovoltaic systems: A review," in *IEEE Bologna Power Tech. Conf. Proc.*, Jun. 2003, vol. 2, p. 8.

[7] T. Kerekes, R. Teodorescu, and U. Borup, "Transformerless photovoltaic inverters connected to the grid," in *Proc. IEEE 22nd Annu. Appl. Power Electron. Conf.*, 2007, pp. 1733–1737.

[8] O. Lopez, R. Teodorescu, and J. Doval-Gandoy, "Multilevel transformer-less topologies for single-phase grid-connected converters," in *Proc. 32nd Annu. Conf. IEEE Ind. Electron. Soc.*, Nov. 2006, pp. 5191–5196.

[9] R.Gonzalez, E. Gubia, J. Lopez, and L.Marroyo, "Transformer-less singlephase multilevel-based photovoltaic inverter," *IEEE Trans. Ind. Electron.*, vol. 55, no. 7, pp. 2694–2702, Jul. 2008.

[10] O. Lopez, F. D. Freijedo, A. G. Yepes, P. Fernandez-Comesaa, 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.

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