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Single phase Transformerless Inverter for Grid-Connected Photovoltaic System

A.S.Abdul Raqeeb[1], M.Arvind[2], S.Bhuvanesh[3], T. Santhosh Kumar[4]

Department of Electrical and Electronics Engineering, SRM Valliammai Engineering College, Kattankulathur, Tamilnadu, India

ABSTRACT: Owing to the benefits of low cost, high efficiency, and light weight, transformerless inverters are widely used in grid-connected photovoltaic (PV) generation systems. However, the problems with common mode voltage have prompted the development of different topologies, control, and modulation systems. A new high-efficiency transformerless topology for PV-grid systems with input from PV panels employing MPPT technology is proposed in this research. The control and high frequency common mode (CM) model are proposed. The suggested topology's inherent circuit structure prevents reverse recovery even when reactive power is injected, allowing MOSFET switches to be used to increase overall efficiency. Low leakage current is achieved bykeeping the CM voltage constant at the center of the dc input voltage.

KEYWORDS: Photovoltaic system, MPPT, Transformerless,

I. INTRODUCTION

Because it is clean, reliable, and emission-free, photovoltaic (PV) energy is considered one of the greatesthopeful renewable energy sources. Furthermore, the PV module has no moving parts, making it a very durable, long-lasting, and low-maintenance device. Though the PV module is still pricey, it has grown increasingly affordable in recent years due to large-scale manufacture. Grid-connected inverters are the major interfaces between PV panels and the utility grid, and are divided into two types: galvoniac isolations and non-isolations systems. To ensure galvanic separation and progress safety, a highs-frequency compacts transformers on the DC side or a line-frequency bulky transformer on the ACs grids sides is commonly used. Unfortunately, due to additional losses produced by transformers and other auxiliary components, the overall efficiency is reduced. The efficiency of a non-isolation or transformerless system can be improved by removing the transformer.

Because of its low cost, great efficiency, small size, and light weight, the transformerless PV inverter system has gotten a lot of attention. The changing CM voltage, which is dependent on the topological structure and switching method in this situation, might create a capacitive leakage current due to the parasitics capacitancesamong the PVs modules and the ground. Leakage current raises grid current harmonics and system losses, deteriorates electromagnetic compatibility, and, most importantly, poses a safety risk. To combat current leakages, numerous PV-fed transformerless inverter topologies and control techniques have been developed. Many topologies have been proposed to rejectoutflow current in transformerless grid-connected PV systems, with the full-bridges invertersby bipolar SPWMs and many unique topologies with unipolar SPWM, such as HERICs, H5s, and H6. The full-bridges inverters with bipolar SPWMs cansassurance a stable common mode voltage and no leakage current, but the twos-levels outputs voltages necessitates a large output filter, which adds losses and lowers power density. However, to supply the grids, a highs DCs buss voltages is necessary, limiting the operational voltages ranges of the PVs panels. The unipolar SPWM method can be used with HERIC, H5, and H6 inverters, which only requires the equal lows DCs buss voltages as full-bridge inverters.

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Therefore, to boost the efficiency, some of the transformerless topologies have been implemented with MOSFET switches because of its low switching and conduction losses. Most of the topologies cannot be implemented using MOSFET switches when inject reactive power. Therefore, the mains focus of this paper is to propose a new topology that can be implemented using MOSFET switches with high reliability, efficiency, and low leakage current even when inject reactive power.

1.1 Xiaonan Zhu et 2022 [1] have been using five level Inverters which is used because of its low voltage stress and its excellent output waveforms. To reduce the leakage current they used five level Inverter. Here the high frequent common mode voltage is avoided and leakage current is neglected. The conduction and switching losses are obtained, analysed and compared atlast the topologies have been made.

1.2 Sumon Dhara et 2021 [5] have been mainly focusing on the elimination of high frequency oscillations by using Half Bridge [HB] configuration. This is done without compromising dc-bus utilization or symmetric operation. PDPWM technique is incorporated in this paper to obtain the pulse signals.

1.3 T. Sreekanthet 2017 [16] have presented about the Single Stage Converter System (SSCS) along with MPPT tracking. This system has several features like low switching loss, high gain and compact size. Here in the proposed system they are using Buck-Boost converter and the output voltage is low and will be varying with time.

II. PROPOSED TOPOLOGY

PV inverters are responsible for converting DC source supplied from PV panels to AC source effectively and reliably, thanks to innovative and dedicated control mechanisms. The MOSFET led topology is a widely used single-phase PV inverter that is connected to the grids via an LCL-filter to ensures the injected current quality. The followings figures depicts the proposed system's basic.

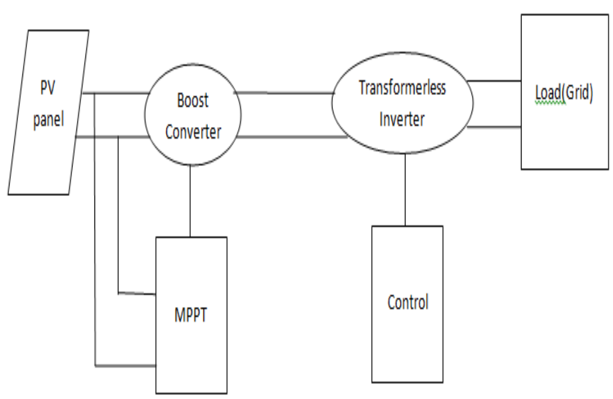

Fig 2.1 Basic Block of Proposed System

III. IMPLEMENTATION OF SINGLE PHASE TRANSFORMERLESS INVERTER

The proposed system gets its electricity from a photovoltaic panel that uses maximums powers points trackingtechnology to drive a boost converter. Six MOSFETs switches(S1-S6) and sixs diodes make up the transformerless inverter scheme (D1-D6). The grid was then connected to an LCL filter device. MOSFET switches respond to control signals in a variety of ways. When injecting reactive powers into the utility grid, the proposed topology aims to addressMOSFET body-low diode's reverse-recovery difficulties. As a result, the proposed topology can be implemented without sacrificing reliability or efficiency using MOSFET switches. Within a grid

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period, the proposed topology's operation principle is divided into four segments. We provide four signals to MOSFETS for these operations. At the load grid, a generalised transformerless inverter's common mode equivalent circuit is used.

Segment 1: In this region, both the grid current and voltage are positive. During the period within this region, S2 is always on, while S1 & S3 synchronously and S5 complementary commutate with switching frequency. There are always two states that generate the output voltage.

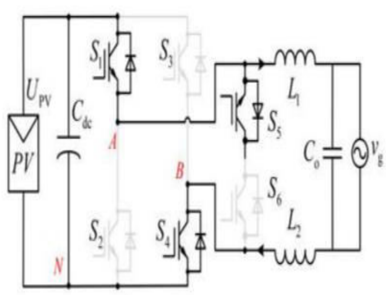

Fig 3.1 Segment 1: State 1

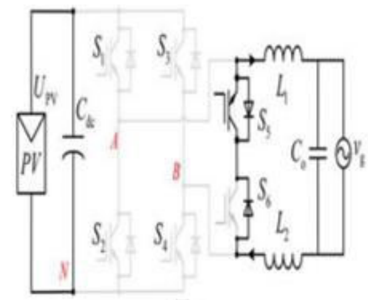

Fig 3.2 Segment 1: State 2

Segment 2:The inverters outputs voltages is negatives in this region, yet the current is positive. S5 is constantly on during this region, while S4 and S6 synchronously commutate with switching frequency, and S2 complementary commutates with switching frequency. The outputs voltages is also generated by two states.

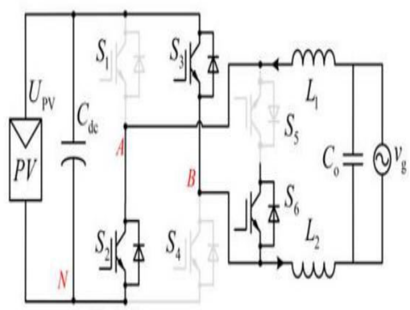

Fig 3.3 Segment 2: State 1.

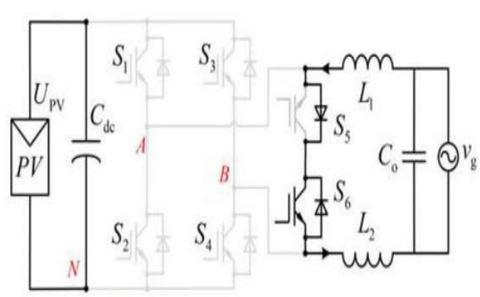

Fig 3.4 Segment 2: State 2

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IV. HARDWARE AND SOFTWARE IMPLEMENTATION

Fig 4.1 Hardware setup

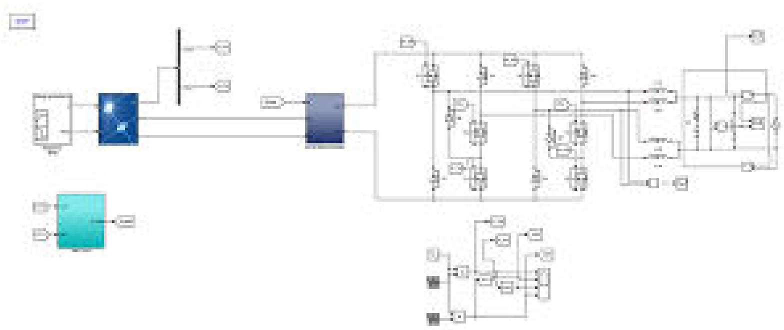

Fig 4.2 Simulation Diagram

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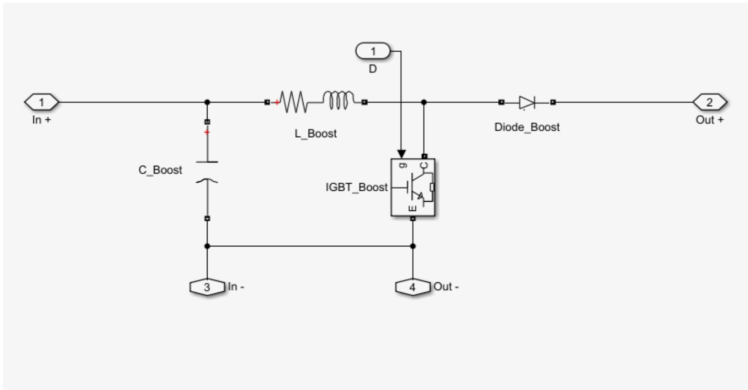

Fig 4.3 Boost Converter Simulation

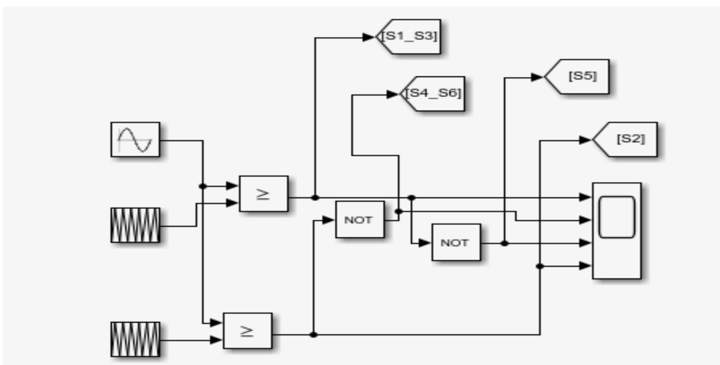

Fig 4.4 Inverter Circuit Simulation

The solar PV array is connected to a Boost converter which is used to obtain maximum efficiency. Then it is attached to MPPT used to track the highest power output generated. Then comes the inverter circuit which consists of 6 MOSFET's and 6 diodes which is so called the controlling circuit and atlast connected to the grid where the power is saved for the later use.

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V. RESULTS AND DISCUSSION

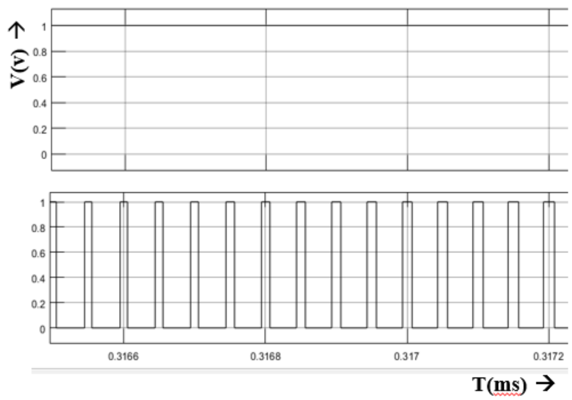

Fig 5.1 Control signals for MOSFETs

It depicts the graphical output waveforms for the MOSFET's used in here. For the control signals here we have used Pulse width Modulation control. Here the graph is plotted between voltage and time. The output waveform of MOSFET gives us voltage (Vdd).

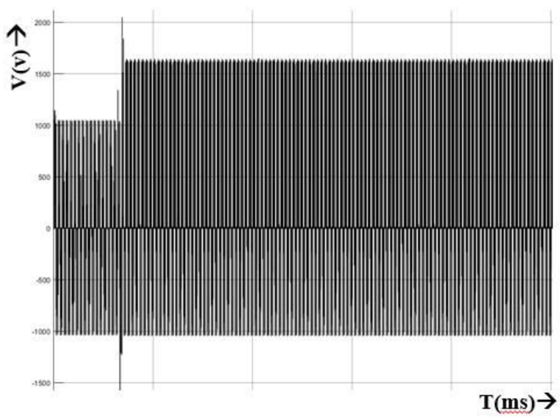

Fig 5.2 Output Voltage

This graphical waveform represents the output voltage obtained from the Inverter circuits. It will be the voltage obtained after conversion of the source from DC to AC.

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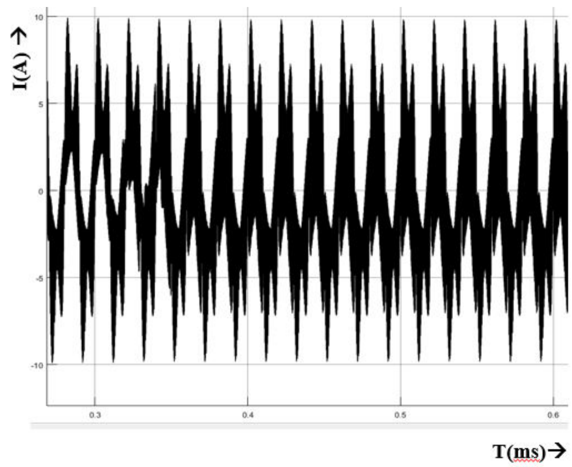

Fig 5.3 Output Current

This graph depicts the output Current waveform obtained from the inverter circuit. This will be the current after the conversion of the power from DC to AC trough the help of Inverter circuits.

Maximum Power (P)	120 W
Open circuit Voltage (Voc)	21 V
Short Circuit Current (Isc)	8 A
Voltage at MPPT (Vmp)	17 V
Current at MPPT (Imp)	7.1 A

Table 5.4 System Parameters

VI. CONCLUSION

A novel transformerless inverter topology was proposed, studied, and shown through experiments. For grid-connected PV applications, it has been verified that the system injects less leakage current into the grid. Due to the boost property, the maximums powers points for PV may be tracked even when the input voltage varies greatly. Furthermore, a modified technique for maintaining balanced voltage over the capacitors has been developed, which can be simply implemented with standard MOSFET systems. In terms of harmonic distortion and current leakage, the four-level operation provides better results. Finally, the inverter's excellent performance was proven.

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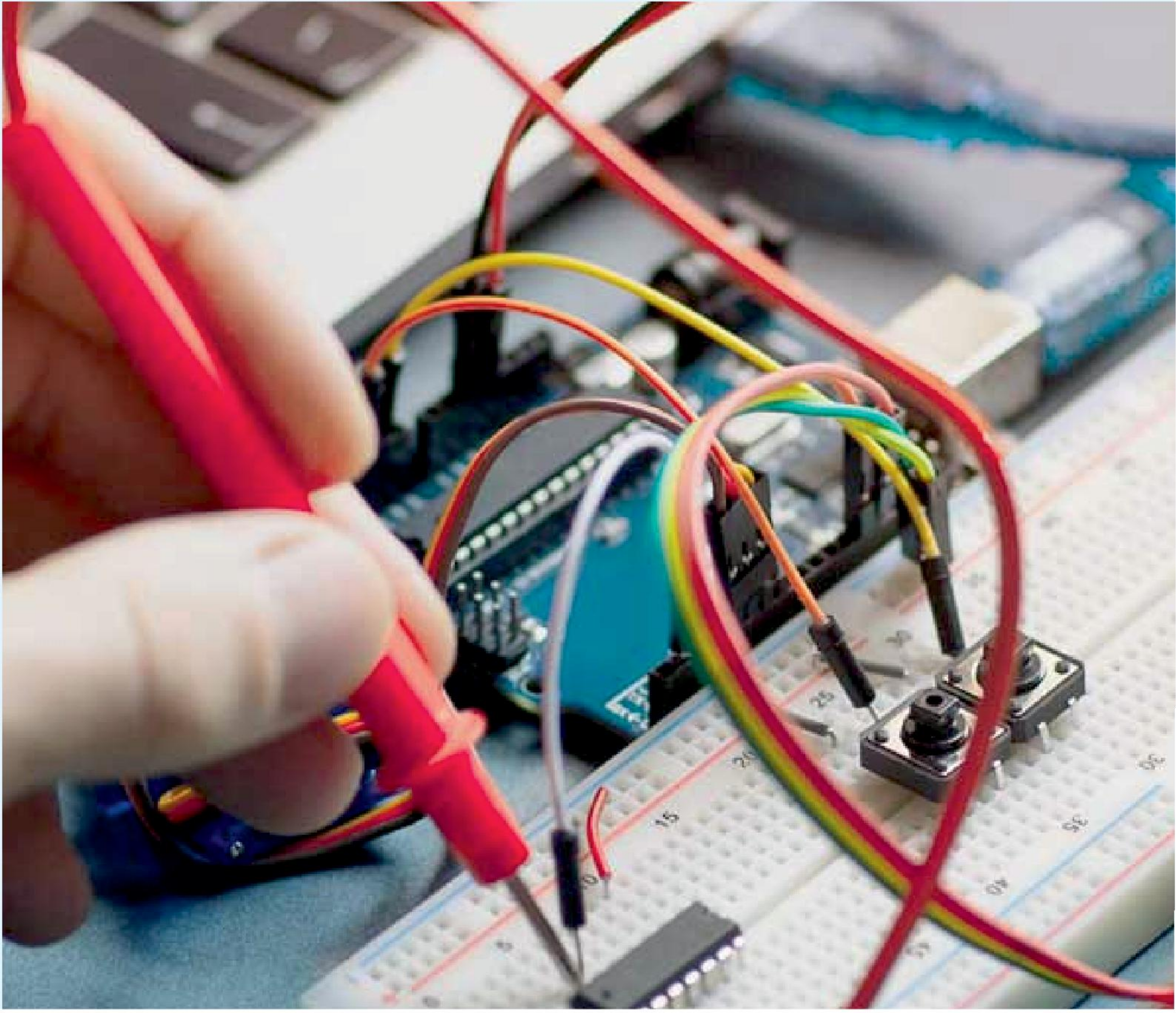

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