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COST EFFECTIVE TRANSFORMERLESS INVERTER IN GRID CONNECTED SOLAR POWER SYSTEM

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Abstract- This paper presents an improved transformer less inverter with common mode leakage current elimination for a photovoltaic grid connected power system .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 eliminate common-mode leakage current. The inverse sine carrier pulse width modulation (ISPWM) control strategy can be applied to implement the presented inverter. The lower total harmonic distortion and higher fundamental output voltage are obtained by using the inverse sine carrier pulse width modulation (ISPWM). The maximum power point tracking (MPPT) is used to extract the maximum power form PV panel. The simulation result of the proposed topology using MATLAB/SIMULINK is presented.

Index Terms- Common mode leakage current, Inverted sine pulse width modulation, Transformer less Inverter, Virtual DC bus

I. INTRODUCTION

A **power converter** is an electrical or electro-mechanical device for converting electrical energy. This could be as simple as a transformer to change the voltage of AC power, but also includes far more complex systems. The term can also refer to a class of electrical machinery that is used to convert one frequency of alternating current into another frequency. Power conversion systems often incorporate redundancy and voltage regulation. One way of classifying power conversion systems is according to whether the input and output are alternating current (AC) or direct current (DC).

A DC to DC Converter

A **DC-to-DC converter** is an electronic circuit which converts a source of direct current (DC) from one voltage level to another. DC to DC converters are important in portable electronic devices such as cellular phones and laptop computers, which are supplied with power from batteries primarily. Such electronic devices often contain several sub-circuits, each with its own voltage level requirement different from that supplied by the battery or an external supply (sometimes higher or lower than the supply voltage). Additionally, the battery voltage declines as its stored power is drained. Switched DC to DC converters offer a method to increase voltage from a partially lowered battery voltage thereby saving space instead of using multiple batteries to accomplish the same thing. Most DC to DC converters also regulate the output voltage. Some exceptions include high-efficiency LED power sources, which are a kind of DC to DC converter that regulates the current through the LEDs, and simple charge pumps which double or triple the output voltage. The **buck–boost converter** is a type of DC-to-DC converter that has an output voltage magnitude that is either greater than or less than the input voltage magnitude.

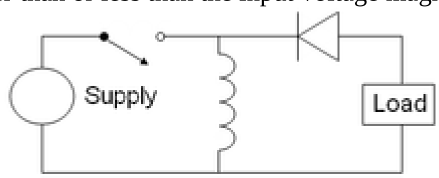

Figure 1: The basic schematic of an inverting buck–boost converter.

The basic principle of the buck–boost converter is fairly simple While in the On-state, the input voltage source is directly connected to the inductor (L). This results in accumulating energy in L. In this stage, the capacitor supplies energy to the output load. While in the Off-state, the inductor is connected to the output load and capacitor, so energy is transferred from Lto C and R.

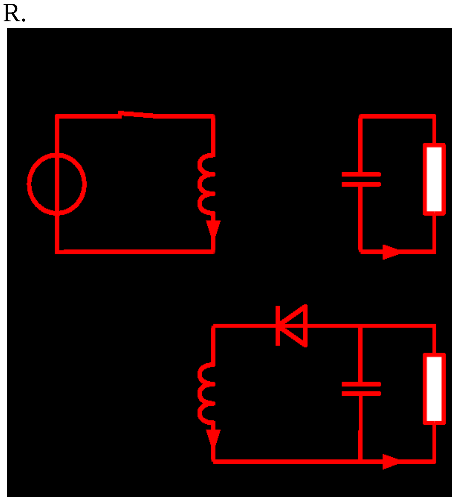

Figure 2: The two operating states of a buck–boost converter When the switch is turned-on, the input voltage source supplies current to the inductor.

II. VIRTUAL DC BUS CONCEPT

The concept of the virtual dc bus is portrayed. By linking the grid neutral line directly to the negative pole of the PV panel, the voltage across the parasitic capacitance *C*PV is clamped to zero. This prevents any leakage current flowing through it. By high opinion to the ground point N, the voltage at midpoint B is either zero or +*V*dc, according to the state of the switch bridge. The purpose of introducing the virtual dc bus is to generate the negative output voltage, which is necessary for the operation of the inverter. If a proper method is designed to transfer the energy between the real bus and the virtual bus, the voltage across the virtual bus can be kept the same as the real one. As shown in Fig. 6, the positive pole of the virtual bus is connected to the ground point N, so that the voltage at the midpoint C is either zero or −*V*dc. The dotted line in the figure indicates that this connection may be realized directly by a wire or indirectly. Supplementary transformer less inverter topologies: (a) Karschny inverter; (b) paralleled-buck inverter ; (c) H6 inverter with capacitor voltage divider. power switch. With points B and C joined together by a smart selecting switch, the voltage at point A can be of three different voltage levels, namely +*V*dc, zero, and −*V*dc. Meanwhile the CM current is removed naturally by the structure of the circuit; there is not any

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limitation on the modulation strategy, which means that the advanced modulation technologies such as the unipolar SPWM or the double-frequency SPWM can be used to satisfy various PV applications.

III. RESULTING TOPOLOGY AND MODULATION APPROACH

Founded on the virtual dc bus concept, a novel inverter topology is derived as an example to show the clear advantages of the proposed methodology. It consists of five power switches S1–S5 and only one single filter inductor *Lf*. The PV panels and capacitor *C*1 form the real dc bus while the virtual dc bus is provided by *C*2 .By the switched capacitor technology, *C*2 is charged by the real dc bus through S1 and S3 to maintain a constant voltage. This topology can be modulated with the unipolar SPWM and double-frequency SPWM. The detailed analysis is introduced as shadows.

A. Unipolar SPWM

The waveform for the unipolar SPWM of the proposed inverter is displayed in Fig. The gate drive signals for the power switches are generated according to the relative value of the modulation wave *ug* and the carrier wave *uc* . Through the positive. Double-frequency SPWM for the proposed topology. Half grid cycle, *ug* >0. S1 and S3 are turned ON and S2 is turned OFF, while S4 and S5 commutate complementally with the carrier frequency. The capacitors *C*1 and *C*2 are in parallel and the circuit rotates between states 1 and 2 as shown in Fig. 10. During the circuit rotates between states 3 and 2. At state 3, S1 and S3 are turned OFF while S2 is turned ON. The negative voltage is generated by the virtual dc bus *C*2 and the inverter output is at negative voltage level. At state 2, S1 and S3 are turned ON while S2 is turned OFF. The inverter output voltage *v*AN equals zero; meanwhile, *C*2 is charged by the dc bus through S1 and S3.

B. Double -Frequency SPWM

The proposed topology can also work with double-frequency SPWM to achieve a higher equivalent switching frequency. In the double-frequency SPWM, the five power switches are separated into two parts, and are modulated with two inverse sinusoidal waves respectively. S1, S2, and S3 are modulated with *u*g1, while S4 and S5 are modulated with *u*g2. In the course of the positive half grid cycle, the circuit rotates in the sequence of "state 4 – state 1 – state 2 – state 1," and the output voltage *v*AN varies between +*V*dc and the zero with twice of the carrier frequency. During the negative half grid cycle, the circuit rotates in the sequence of "state 4 – state 3 – state 2 – state 3," and the output voltage *v*AN varies between −*V*dc and zero. The aforementioned two modulation strategies both have their own advantages. The double-frequency SPWM can provide a higher equivalent switching frequency so that the size and weight of the filter inductor can be reduced. On the other hand, the unipolar SPWM can guarantee that the virtual dc bus *C*2 is charged by the real bus every switching cycle, so that the current stress on S1 and S3 caused by the operation of the switched capacitor can be reduced. In this paper, the unipolar SPWM is chosen as an example for the performance evaluation and experimental verification. Equivalent circuits for states 2 and 3: (a) state 2; (b) state 3. For all of the four operation states, there is no limitation on the direction of the output current *i*grid, since the power switches with antiparallel diodes can achieve bidirectional current flow. Therefore, the proposed topology has the capability of feeding reactive power into the grid to help support the stability of the power system. The proposed topology is also immune against transient overvoltage of the grid. During the mains positive voltage spikes, the voltage at point A is clamped at *V*dc by *C*1 and the anti parallel diodes of S1 and S4 . Similarly, during the negative voltage spikes, the voltage at point A is clamped at −*V*dc by *C*2 and the anti parallel diodes of S2 and S5. Therefore, the mains transient overvoltage does not pose a safety threat for the inverter.

IV. MATLAB / SIMULINK MODEL

A. The Fig.8 shows the MATLAB / Simulink model for proposed inverter topology.

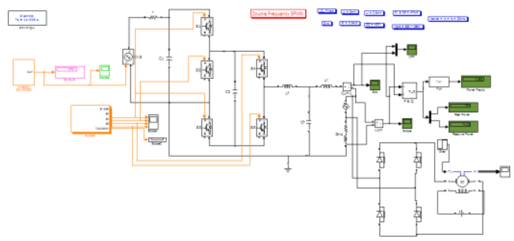


Fig 3: Simulink Model For Proposed Topology

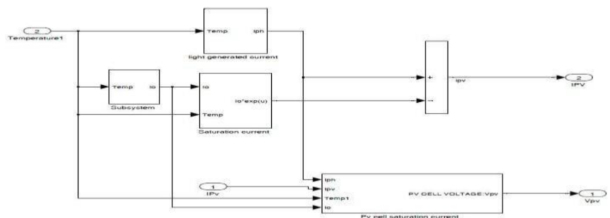
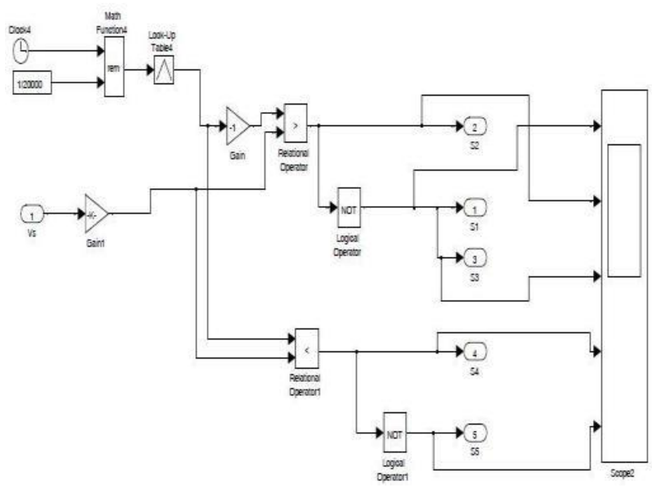
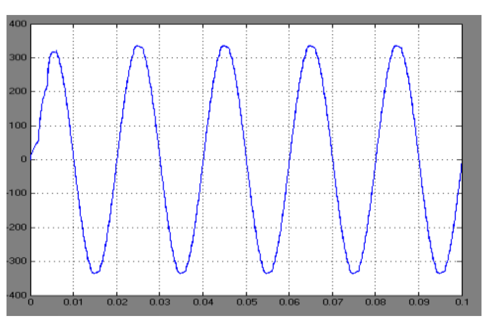
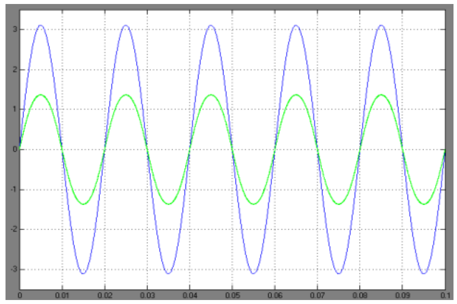
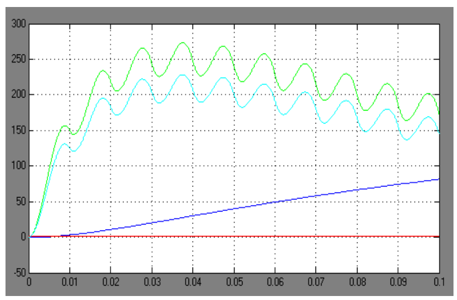


Fig 4. Simulink Model For Solar PV Cell









Dc motor wave forms

Fig 5. Simulink model for unipolar SPWM

V. CONCLUSION

The concept of the virtual DC bus is proposed to solve the CM current problem for the transformer less grid-connected PV inverter. By connecting the negative pole of the DC bus directly to the grid neutral line, the voltage on the stray PV capacitor is clamped to zero. This eliminates the CM current completely. Meanwhile, a virtual DC bus is created to provide the negative voltage level. The required DC voltage is only half of the half bridge solution, while the performance in eliminating the CM current is better than the full bridge based inverters. Based on this idea, a novel inverter topology is proposed with the virtual DC bus concept by adopting the switched capacitor technology. It consists of only five power switches and a single filter inductor. The proposed topology is especially suitable for the small power single phase applications, where the output current is relatively small so that the extra current stress caused by the switched capacitor does not cause serious reliability problem for the power devices and capacitors. With excellent performance in eliminating the CM current, the virtual DC bus concept provides a promising solution for the transformer less grid-connected PV inverters. The software tool used in this project is MATLAB 2011b.

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