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Transformer Less Self-Commutated PV Inverter

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Abstract: ***The power demand is increased day by day and generation of electrical energy from non-renewable sources are not able to meet the demand. An alternate energy sources are the only solution to meet the power demand. The power generation from solar energy with photovoltaic effect is plays a major role. This Solar PV system has low efficiency. The power semiconductor devices and converter circuit along with inductive / magnetic circuit. The Inverter circuit have an influence on photovoltaic power generation to improve the level of output voltage along with efficiency. In this paper a new transformer less DC-AC converter is proposed, and it has high efficiency, requires less cost when compares with conventional inverter with transformer. Transformer less self-commutated photovoltaic inverter is reflected the advantages of central and string inverters. It gives high output power and low-cost converter. These transformer less DC-AC converter is connect with Boost/Buck-Boost converter for the better output. So, this proposed DC-AC converter topology is not required mechanical switching and it is lighter in size. The PV technology has low efficiency and utilize more cost for generation of power. The proposed transformer less PV inverter is the better choice to increase the usefulness and reduce the charge rate of this PV system.***

Keywords: DC-AC Converter, Inverter without Transformer, PV technology, Simulink- MATLAB.

I. INTRODUCTION

The pollution free atmosphere and power demand fulfilment leads to develop a distributed renewable energy power generation. The power demand is higher than power generation and it leads bad impression on energy worthy, safety, security. The resolution for disabling this issue is to generate more power using non-conventional sources. There are many non-conventional sources are available in this world. But, the solar PV system has low efficiency power generation. To reduce the cost and enhance the effectiveness of the PV system the power electronic converter is integrated with these technologies. The solar irradiation energy is freely available in this world and it is present in all over the world. The conventional energy sources are depleting day by day. This PV system does not have any rotating parts. Hence, PV technology is most preferred with power converter integration. It reduces the losses due to transmission lines and does not create pollution to the environment. The proposed transformer less inverter will improve the power output than the normal conventional inverter. The efficiency of the proposed inverter circuit increased by proper sequential switching of the circuit. Because of the above-mentioned reasons, the inverter without transformer has designed in this paper. It provides the isolation by means proper sequential switching and magnetic circuit.

DC-AC converters are popular in many of the industrial application inorder to provide high power, variable voltage, and variable frequency. These inverter circuits are simple and easiest converter to integrate the renewable sources for applications like high power, high voltage. The DC-AC converters gets the DC input power from renewable sources like solar PV, fuel cell, ultra-capacitors, capacitors, battery.

The proposed DC-AC converter has the following features. It produces high quality output waveforms, produces high voltage in the output side. It has small switching loss and works with high and low fundamental PWM switching frequency. It has less Total Harmonic Distortion (THD) and reduced electromagnetic interference problems. Even though it has many features the main limitation of this inverter is the high number of power semiconductor switching devices. The gate driver circuit is required for each semiconductor switches and it increases the difficulty of the controller circuit designing.

Because of the increasing number of switches, the system becomes costlier. So, many researchers have started to reduce the number of power semiconductor switching devices of the system and decrease the level of complexity of system controller circuit designing. The inverter system requires grounding. This paper deals with transformer less self-commutated DC-AC converter for PV applications.

II. TRANSFORMER LESS PV INVERTERS

A. Problem Statement

The photovoltaic system generates electricity from solar irradiation and it feeds the power to grid through an power electronic converter circuit. It may require isolation or non-isolation from grid. Hence, the DC-AC converter is also isolated or occasionally non-isolated based on the panel and grid isolation topology. This isolation is achieved by the static device transformer. It will improve the isolation between converter and grid. Every country has its own grid code regulations based on it the isolation provided by the transformer. The step-up transformer with low frequency is used in the grid side and stepdown transformer with high frequency can be used in the input side of inverter circuit.

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B. Concept of Proposed Converter

In many countries the isolation between the photovoltaic panel and the grid is achieved through inverter with transformer circuit. But, in countries like Spain uses an alternative solution for providing isolation between solar panel and the grid. The transformer less isolation enhances the efficiency of the system and reduces the losses and size of the entire system becomes lighter. The cost and controller designing difficulties are also reduced by the transformer less isolation system. In the proposed concept of isolation without transformer increases the system efficiency. So, the transformer less PV inverter circuit is proposed and designed in this paper. But, the limitation of the transformer less DC-AC converter is that injecting the DC currents into the AC output of the inverter circuit due to the absence of low-frequency transformer.

III. IMPLEMENTATION OF PROPOSED TRANSFORMER LESS PV INVERTER

A. Transformer less inverter topologies

The DC-AC converter may have one or two stages of conversion based on the outputs required. The block diagram of one stage and multiple stage power conversion of PV inverters integrated with distributed grid is shown in given Fig.1 and 2.

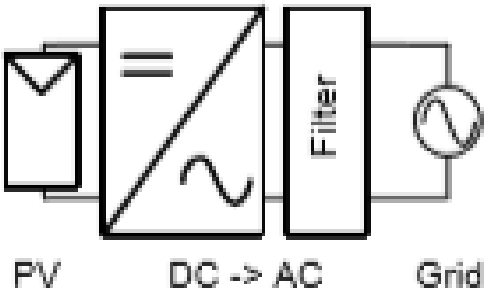

Fig. 1. One stage PV DC-AC converter integration with grid

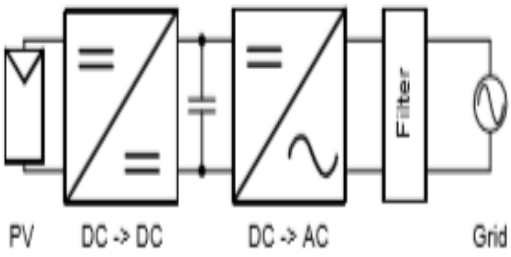

Fig. 2. Two stage grid connected PV inverters including Voltage Boost

B. Proposed Converter Topology

Transformer less inverter is noteworthy, extremely attractive according to the low cost, less weight and smaller in size, improvement in efficiency. Many of the researchers are concentrating on transformer less DC-AC converter based PV system designing. The solar irradiation is not in constant level throughout the day. The Boost converter is used to integrate with transformer less system in order to provide the constant, large value of DC output from the variable, unbalanced, lower inputs received from the solar PV system. The converted Large value of DC output voltage is applied into the transformer less inverter circuit which starts converting it into variable AC voltage. In this proposed system DC-DC converters are used to convert the input voltages and transfer the input solar power into the distributed grid along with transformer less inverter. The stable, high DC output is fed into the inverter circuit great, DC input is fed to the inverter which converts the DC high input voltage to the AC voltage. This converter is operated in boost/buck mode. If the converter is operates in buck mode the lowest DC value power is given to the inverter and power factor value is controlled and utility voltage is also controlled. The inverter is fed into high DC output voltage when the converter operates in boost mode. The Solar PV panel has low-voltage characteristics. So, the solar PV panels output is not highly enough to supply the higher value of voltage into the inverter circuit. So, we need to make the DC-DC converter to operate in boost mode. The transformer less DC-AC converter topology is used to connect the intermittent solar irradiation source by the boost DC-DC converter and are useful to connect the low voltage PV panel into the grid. In this paper, the solar-panel cells unit is designed to produce the output voltage of approximately 190 in the maximum output power condition (i.e., 2.5kW).

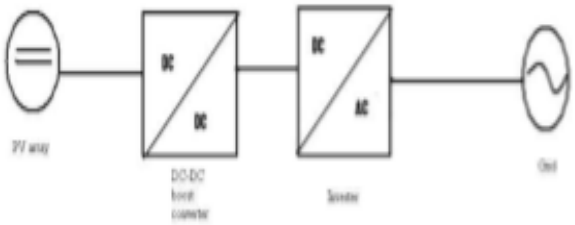

Fig. 3. Block Diagram of Transformer less Inverter with DC-DC Boost Converter

The solar PV panel arrangement has an impact on output voltage levels and it disturbs the entire system design.. The conventional inverter system requires high voltage because the system utilized voltage is 230V and it reaches the peak as 400V.Inorder to get the stable and constant input voltage, a high value of capacitor is connected in front of the inverter circuit. It is used to extract the ripple power supplied by the utility. The buck/boost converter and transformer less inverter provides the power along with high switching. Hence, it leads large value of switching losses.

IV. RESULT AND DISCUSSION

A. SIMULINK Model of Proposed Converter Topology

This proposed converter has developed using MATLAB to verify its effectiveness.

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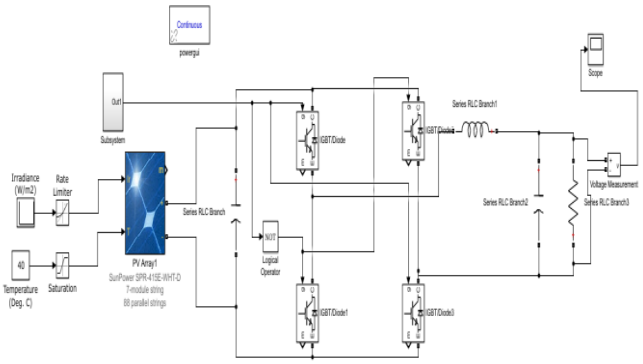


Fig. 4. SIMULINK Model of Transformer Less Self Commutated PV Inverter

The simulation diagram of proposed converter topology is represented in Fig.4.

B. Pulse Width Modulation Technique

The gate drive signal for the switching devices are generated by the PWM technique. This power is applied to the load controller by the pulse width variation principle. The gate pulses are generated by comparing the two different signals and these signals are in constant frequency, magnitude. The constant/fixed dc voltage is applied to the inverter and the inverter circuits are controlled by providing the pulses in an sequential manner. The modulation signal is controlled period to period. The integration connection between supply, DC-DC converter and PWM inverters with grid. The pulses for the gate terminals of the controlled semiconductor inverter devices like transistor supplies the variable pulse width. So, the switches ON/OFF time of the switching device is controlled. that transistors is generated and applied it controls When a PWM signal is applied to the gate of a power transistor, it causes the turn on and turns off intervals of the transistor to change from one PWM period to another PWM period according to the same modulating signal. The PWM signal operating frequency is more than the modulation signal output. The frequency of a PWM signal must be much higher than that of the modulating signal, the the fundamental frequency, such that the energy delivered to the motor and its load depends mostly on the modulating signal. The triangular waveform is the carrier wave and its compared with the sinusoidal reference wave to generate the pulses for the semiconductor switching devices in sinusoidal PWM technique. The pulse generation block is shown in Fig. 5.

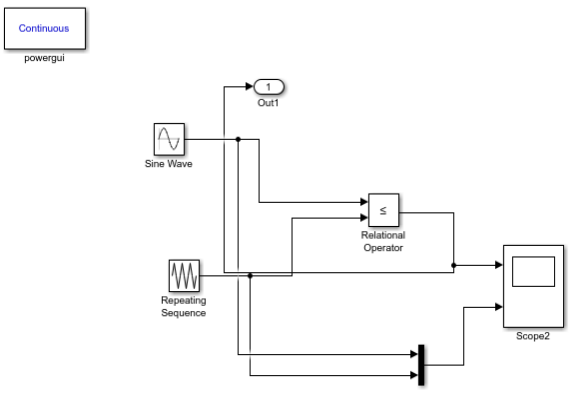


Fig. 5. Sinusoidal PWM Technique

C. Output of the proposed inverter

The presentation of the proposed Transformer less Photovoltaic inverter system with single or double stage topology is enhanced and achieved. These proposed converter topologies is simulated with the Matlab/Simulink software. In the simulation, the output waveforms are obtained and it is shown in Fig. 6.

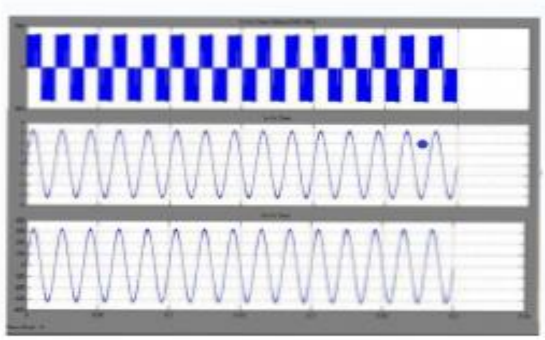
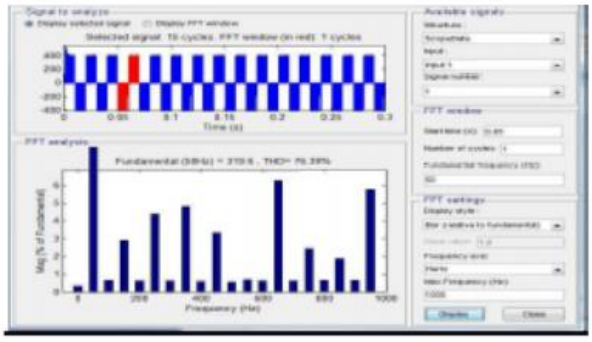


Fig. 6. Output Waveforms of Proposed inverter Topology

The FFT analysis of the proposed power converter is shown in Fig. 7.



V. CONCLUSION

In this paper a new transformer less PV converter is presented. This proposed topology has been achieved by integrating Boost DC-DC converter with single phase inverter. This proposed PV converter is simulated using MATLAB/Simulink. It is integrated with PV system for improving their performance. Compared to classical PV, proposed converter provided better efficiency, less weight, high power output and improved dynamic response because of the absence of transformer in DC-AC converter.

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