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Single Phase Transformer Less Inverter for Grid Connected Photo Voltaic System

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ABSTRACT

Sustainable power generation systems have been developed as a result of increased consumption of energy, the rapid depletion of fossil fuels, and environmental degradation worldwide. Thus, the demand for photovoltaic systems is increasing, owing to the increased need for renewable resources worldwide. Transformers are often used in photovoltaic systems to offer voltage ratio conversions between input and output along with galvanic isolation. The inverter, that may be a transformer-less or with a transformer, is the enabling technology in PV systems. But, the efficiency and power density of these traditional iron and copper-based transformers are decreased while the inverter's weight, size, and cost are increased. Thus, it is recommended to refrain from utilizing transformers within the inverter. For this reason, transformer-less inverters for grid-tied, low-voltage, single-phase photovoltaic (PV) systems have gained more attention thesedays. To comply with the safety requirements imposed by grid regulations, there are a few distinctive challenges, particularly with respect to leakage current problems, which need to be sufficiently handled. Owing to this In recent years, distributed solar grid-tied systems have made widespread use of single phase transformerless Voltage Source Inverters.

This paper explores a novel transformer-less solar inverter for grid connected PV system and Results are investigated in MATLAB Simulink provided a significant reduction in distortion in voltage and current at load side.

Keywords : Photo Voltaic , Pulse Width Modulation, Total Harmonic Distortion,, Common Mode Voltage, Transformerless Inverter, Leakage Current.

I. INTRODUCTION

The most promising renewable energy source thesedays is solar PV. Solar energy installations are predicted to reach terawatts worldwide [1]. Improved performance, cheaper costs, and lighter designs are some advantages of PV system. [2]

There are two methods for integrating PV power into the grid: with or without a transformer. Between the PV and the grid, galvanic isolation develops when the transformer is used in conjunction with an inverter. [3] However, because a transformer is needed, the system is heavy and bulky. Employing transformerless inverters that doesn't have a transformer is the alternative method. This transformerless inverter has two ways to connect to the grid: a single-stage structure and two-stage configuration as shown in Fig.1 and Fig.2 respectively. [4]

Due to several benefits including lower inverter costs, greater conversion efficiencies, and smaller size/weight, transformer-less grid-tied inverters have become a realistic option for solar power generating systems in the low- to medium-sized solar power range. [5]

Electronic interface, which consists of VSI and boost converter, is used to link the solar PV array to the grid. A crucial component of converting DC power into grid-interactive AC voltage is an inverter. A high frequency transformer is located on the DC side of the inverter, while a low frequency transformer is located on the AC grid side. Even while the transformer suppresses leakage currents between PV and the ground, providing galvanic isolation and protection, the losses incurred by the transformer lead to a decrease in efficiency. While removing the transformer reduces costs, makes a space smaller, and boosts efficiency, galvanic isolation is lost in the process. Absence of it causes a parasitic capacitance between the PV system and the ground, which leads to leakage current. The inverter, filter, and grid impedance is used to generate a common mode resonant circuit with this DC-side ground parasitic capacitance. [6]

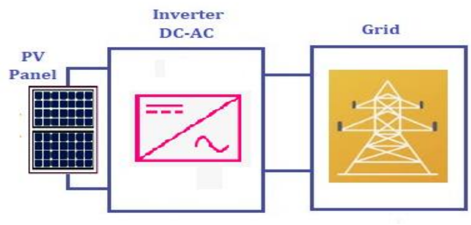

Fig.1. Single Stage

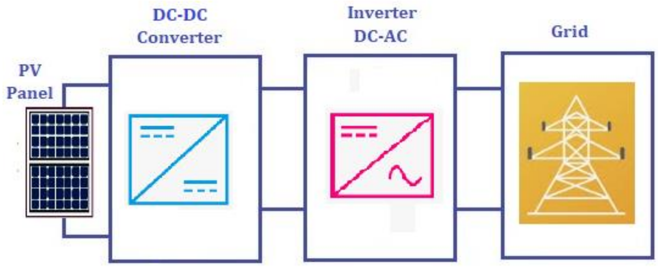

Fig.2. Two Stage

Due to leakage current from the PV to the ground parasitic capacitance, this common mode circuit forms a conducting route that leads to the inverter. This current passes via the transformer's stray capacitance when a transformer is present. The primary cause of this leakage current circulation is the lack of galvanic isolation, which also raises harmonic content and causes electromagnetic interference (EMI) between the PV panel and the grid. The amplitude and frequency changes of PV voltage are primary factors influencing the leakage current. The maximum leakage current permitted in relation to the disconnection time between the grid and the inverter has been capped by a number of standards. [7]

Removing transformers will result in a loss of galvanic isolation between the PV and the grid, which allows current to leak between the PV's stray capacitance and the grid. [8]

Leakage current results in significant losses and occasionally person in contact with the panel may receive the shocks. In transformer-less topology, either DC-decoupling or AC-decoupling can provide the galvanic isolation. Due to fewer switches in the conduction channel, it is observed that ac-decoupling has lower loss than dc-decoupling.

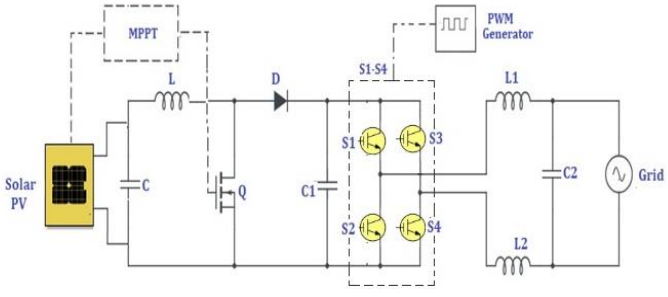

Fig. 3. Proposed Scheme

In transformer-less topologies, incorrect Common Mode Voltage clamping is another cause of leakage current. In order to completely eliminate the leakage current, galvanic isolation and appropriately clamped Common Mode Voltage are required. [9]

Therefore, this study seeks to thoroughly examine and classify numerous transformerless inverters with extensive comparisons in order to offer a clear view on the development of transformerless inverters for the future generation grid-connected PV systems.

II. Proposed Scheme

In many instances, the PV cell functions as a current-dependent voltage source, with an output that is reliant on current and is determined by insolation and irradiance. In this proposed work the solar PV is fed to the boost converter The boost converter's output is regulated while being sent to the inverter. The scheme doesn't include a transformer since it adds complexity and creates losses to the system. Boost converter is supplied to the inverter circuit and further fed to the grid through the LCL filter circuit,.
Bipolar modulated pulses have been employed for switching the gates of inverter switches. The scheme provides lesser THD profile in voltage as well as current. The block proposed diagram of the overall system is shown in Fig.3.

A. PV Module

The term "solar module" or "PV module" refers to the grouping of interconnected solar cells. So as to boost the power output, the cells can be linked in parallel or series. Numerous PV cells are connected in series to generate a greater voltage and in parallel to enhance current in a PV module. For big power generation, the industry norm is 36 cell modules. [10]

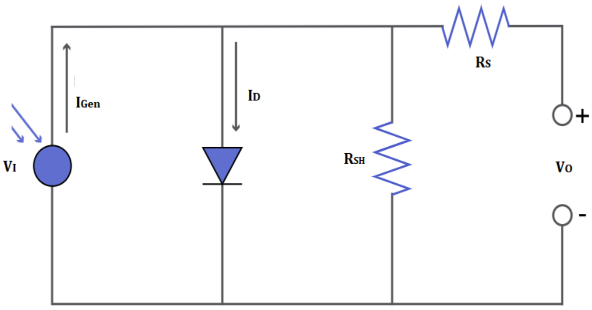

Fig.4. Equivalent Circuit for PV

Typically, the PV cell functions as the output of a current-dependent voltage source is determined by current, which is influenced by irradiance and insolation [11]. A diode may be used for imitating the solar cell as an anti-parallel current source. When a cell is exposed to light,

Direct current is produced; this current fluctuates linearly with changes in solar radiation.

B. Pulse Generator

Fig.5 shows PWM generator, which produces a steady frequency PWM signal with a flexible duty ratio. Here Sine wave is compared by saw-tooth one to generate necessary PWM pulses for inverter.

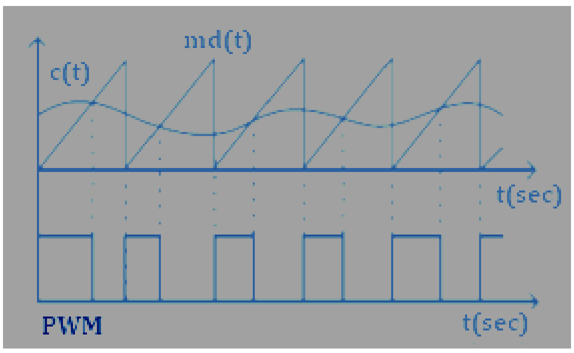

Fig.5. Pulse Generation

III.Simulations and Result

This section comprises illustrations for the suggested inverter system's Simulink model. A PV cell, boost converter, inverter, PWM generator, and filter constitute the parts of the model. MATLAB is used to study the proposed design and to analyze the transformerless inverter's performance.

Fig.6 illustrates the Simulink design for the transformerless inverter scheme that respects the transformerless inverter scheme.

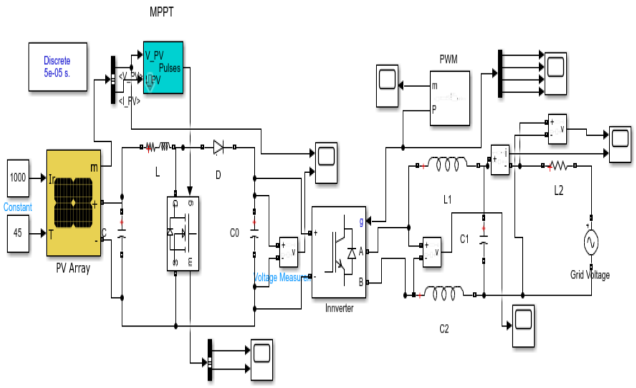

Fig. 6. MATLAB Model for Proposed System

Fig.7 and Fig.8 are input PV voltage and elevated boost voltage respectively. Here 230V from PV is boosted at 340 using boost converter which is controlled by Maximum Power Point Tracking scheme

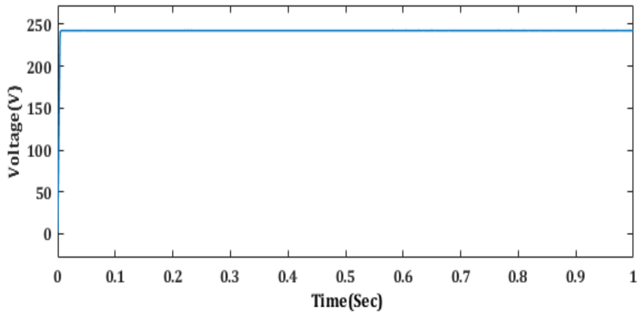

Fig.7. PV Voltage

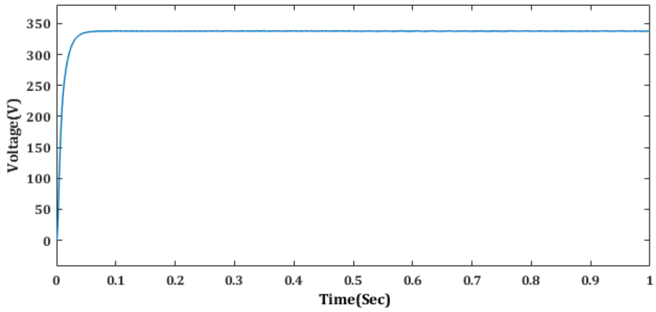

Fig.8. Boost Voltage

PWM pulses are fed to inverter switches for switching purposes .these pulses are generated by employing bipolar modulation in PWM generator. The PWM pulse waveforms for the inverter switches are shown in Fig.9. Four pulses are given to inverter switches for appropriate switching so as to get AC square waveform from the DC one

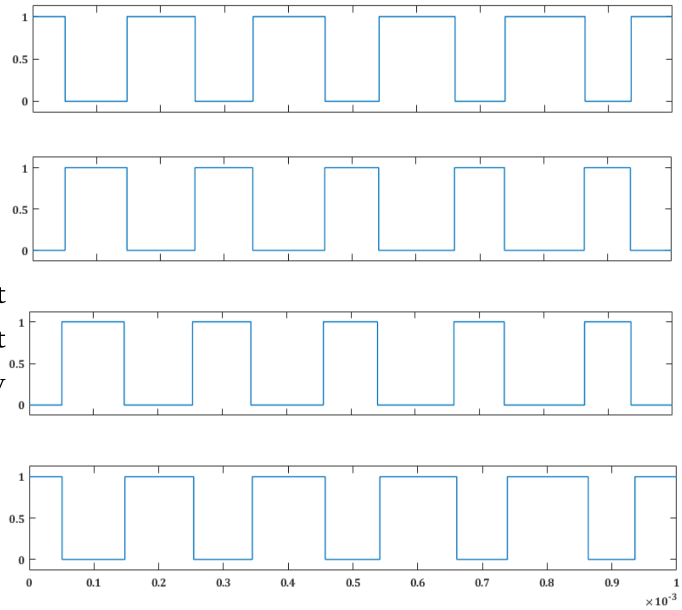

Fig.9. PWM Pulses

Fig.10 depicts the inverted voltage from the inverter of 340V prior to filter circuit.

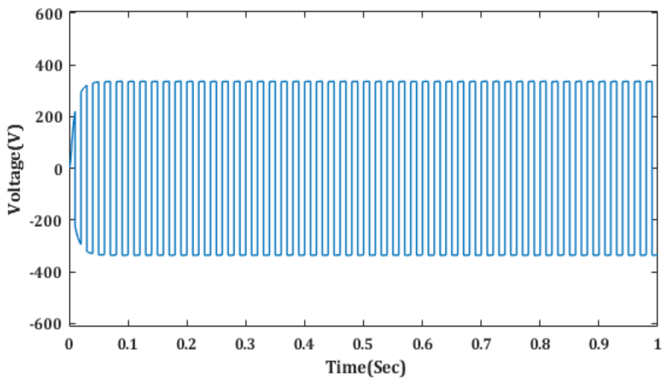

Fig.10. Inverter Output

The output voltage at the grid side is shown in Fig.11 . It is of 270 V and respective THD profile for voltage waveform is found to be 2.39% which is shown in Fig.12.

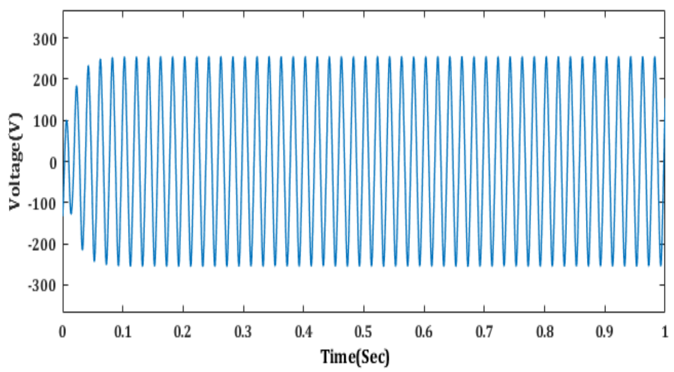

Fig. 11.Voltage Waveform

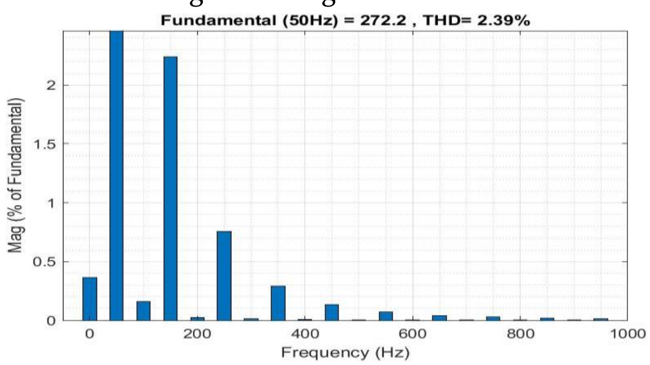

Fig.12. THD Profile for Voltage

The output current at the grid side is shown in Fig.13 . It is of 21A and respective THD profile for voltage waveform is found to be 3.07% which is shown in Fig.14.

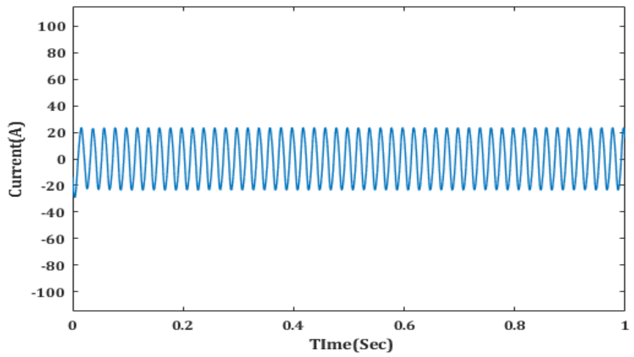

Fig.13. Current

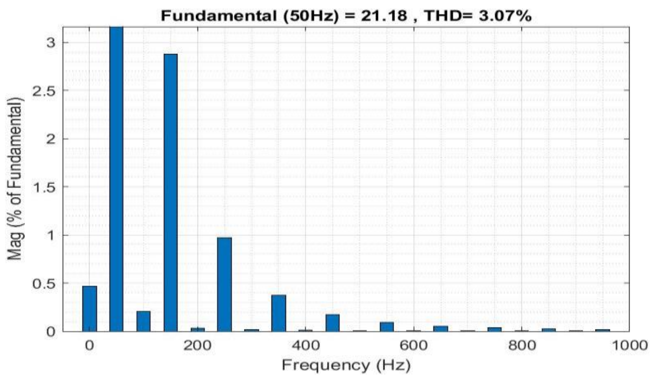

Fig.14. THD Profile for Current

IV. CONCLUSION

In this paper a novel transformer less PV converter is presented. The intended topology is designed with integrating Boost converter along with single phase inverter. This PV converter scheme is simulated using MATLAB.

The result from the simulation shows how solar electricity may be effectively transformed into AC power without the need for transformers. Due to the DC-AC converter's lack of a transformer, the suggested converter offered higher power output, less weight, better efficiency, and increased dynamic response.

In order to lower system weight and expense, intermediary links can also be eliminated.

The proposed PV inverter succeeds in generating better response, whereas the output of inverter was just about sinusoidal and harmonic values that complied with international requirements of IEEE 519 standard. Furthermore, the harmonic distortions for voltage and current waveforms are found to be in permissible limit that are 2.39 % and 3.07 % respectively.

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