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Comparative Analysis of Traditional Inverter and Z-Source Inverter for PV System

KEYWORDS: Impedance-source inverter, Renewable energy sources, PV system, solar cell,

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ABSTRACT *In this paper two different inverters: traditional inverter and Z-source inverter for photo voltaic (PV) system were investigated. Total power of each of these inverters was calculated. For purposes of power comparison the inverters are interfaced with PV system. The input from PV system is given as inputto single input DC-DC converter. The regulated output voltage from DC-DC converter is taken to three phase inverters with load arrangements. The power levels in both the cases are compared through simulation results and they are made known to substantiate the qualities of traditional inverter and Z-source inverter systems for PV system. This comparison shows that the Z-source inverter is very promising for PV system.*

I. Introduction

Renewable energy sources gain their energy from existing flow of energy, from on-going natural processes, such as sunshine, wind, flowing water and geothermal heat flow as has been shown (R.Gules, J.De Pellegrin Pacheco, H.Leaes Hey and J.Imhoff , IEEE 2008) . As the PV energy from sunshine has the greatest potential of all the sources of renewable energy, it is the most feasible alternative energy source with a disadvantage of high unpredictability. However, PV power has to be utilized in effective manner. Hence different systems were developed with various topologies of converters and controllers. Due to the advancements of Power Electronics and Digital Control Techniques, control and execution of renewable energy systems are made promising as John Marshal (IJERA 2012) mentioned. Some of the available topologies are detailed in this paper.

II. Photovoltaic System

PV generation of electricity is clean, inexhaustible source of power. A photovoltaic system uses one or more solar panels to convert PV energy in to electricity. It consists of photovoltaic module, mechanical, electrical connections and mounting for regulating and/or modifying the electrical output.

When photovoltaic cells becomes exposed to light beam the current is generated. According to the nonlinear output and principles of PV power generation different simulation models are obtainable by the MATLAB/Simulink software packages. An equivalent circuit of PV cell as John Marshal (IJERA 2012) mentioned is developed for basic analysis of PV cell. The circuit contains a constant current source as the current is considered as constant, and the voltage changes based on the photovoltaic cells exposure to light beam. The equivalent circuit model is shown in figure1 and the cell electrical characteristics as John Marshal (IJERA 2012) mentioned are shown in figure2.

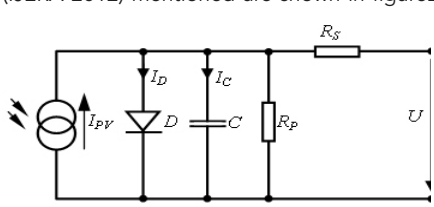

Figure1. Equivalent circuit of solar cell

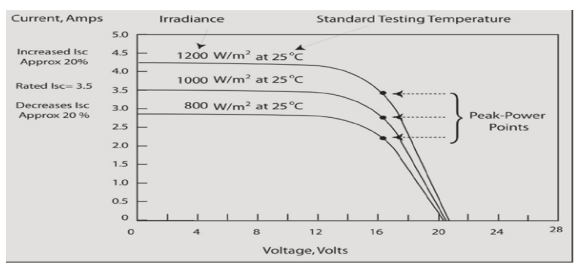

Figure2.Electrical characteristics of PV module

The role of a photovoltaic system differs due to the variation of the intensity of the solar radiation with respect to time. When the light of a PV cell, which supplies an electrical resistance, changes, the power point shifts. This point is illustrated in figure2. The graph presents peak point in the knee of the electrical characteristics. The maximum power which a PV cell can produce is product maximum voltage of PV cell and maximum current of PV cell. Using the maximum power and the appropriate electrical characteristics the fill factor, the key characteristics in evaluating PV cell performance can be calculated.

III. Fundamentals and Configurations of Traditional and Z-source Inverter

A. Traditional Inverter:

The traditional voltage source inverter shown in figure3 consists of a diode rectifier, DC link and inverter bridge. To get better power factor, either an AC or DC inductor is generally used. The traditional voltage source inverters are characterized by low efficiency due to switching losses and EMI generation. Here power MOSFET switches and anti parallel diodes are used in the main circuit. This arrangement provides bidirectional current flow and unidirectional voltage blocking capability. Hence inverter presents negligible switching losses and EMI generation at the line frequency. Here the amplitude of output voltage does not depend on the load. However the amplitude of output current depends upon the load.

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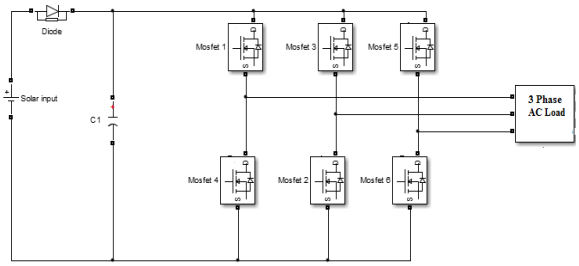

Figure 3.Traditional PWM Inverter

B. Impedance Source Inverter:

For renewable energy systems the foremost dispute is the output voltage difference of the input energy source. This inverter can provide buck-boost operation. Impedance source inverter deploys an impedance network coupled with the inverter main circuit. With a distinct impedance network consisting of inductors and capacitors, the impedance source inverter uses the shoot through state by firing on both the upper and lower switches in the same phase legs to boost the DC voltage without DC/DC converter. F Z Peng and Yi Huang found.

The network also forms a second order filter that handles undesirable voltage sags of the DC voltage source. The inductors and capacitors can be optimally designed to lower the cost and size of inverter circuitry.

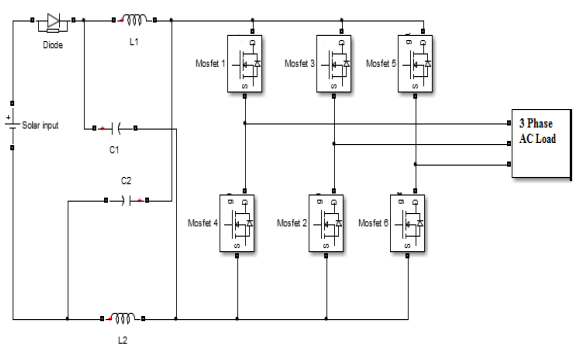

Figure4.Impedance Source Inverter

As in case of conventional inverters, the impedance-source inverter system shown in figure 4 does not require massive transformers or DC/DC converters to boost the voltage. Since there is no requirement of dead time, the control accuracy and harmonics are improved. The impedance-source inverter has the least amount KVA prerequisite for most renewable energy sources. Besides all these, the impedance-source inverter system is able to track the maximum power and voltage boost concurrently and separately by a single inverter. F Z Peng and Yi Huang found. The diode prevents the discharge of charged capacitor through the source.

IV. Simulation Results

Case I: Traditional Inverter for PV System:

Traditional voltage source inverter using solar cell is shown in figure 5.

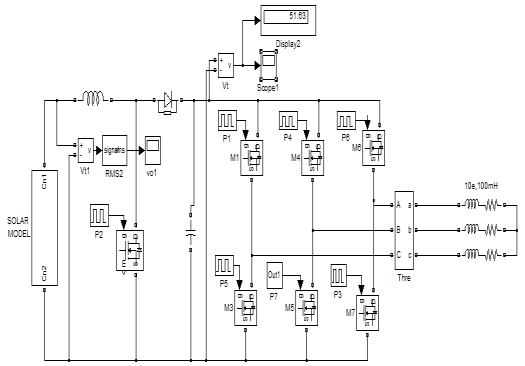

Figure 5. Traditional inverter using Solar cell

DC output voltage of solar cell feeding voltage source inverter is shown in figure 6.Its value is 24V.It is boosted (stepped up) to nearly 48V using boost converter as shown in figure 7. The output of the boost converter is converted in to three phase AC using traditional voltage source inverter. The output contains three voltages displaced by certain degree as shown in figure 8. The phase currents are shown in figure 9.Through photovoltaic cell based traditional voltage source inverter system the simulated value of power in watts is 28.

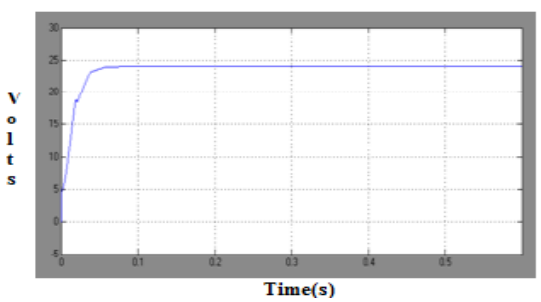

Figure 6. Output voltage of PV cell

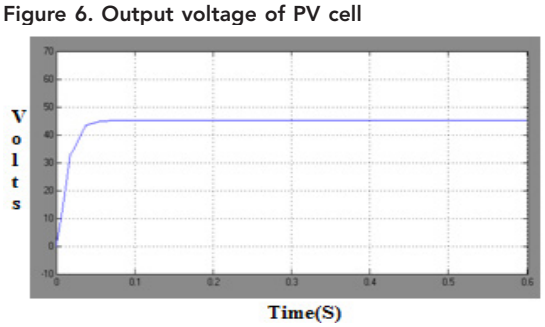

Figure 7. Output voltage of boost converter

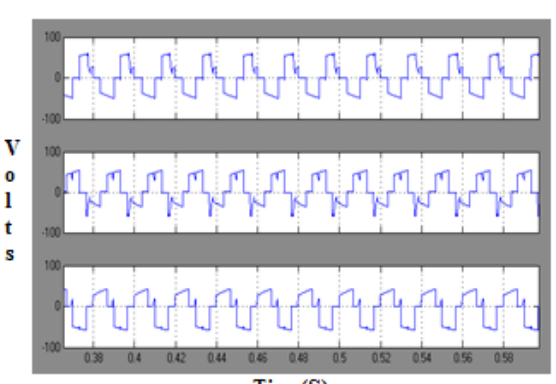

Figure 8. Output phase volatge of inverter

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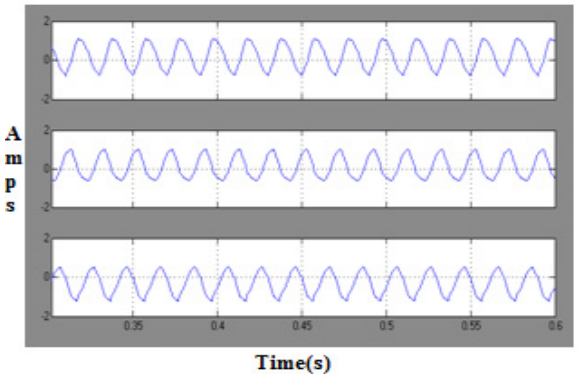

Figure 9. Output phase current of inverter

Case II: Z-Source Inverter for PV System: Impedance-source inverter consisting of pair of capacitors and inductors using photovoltaic energy is shown in figure 10.

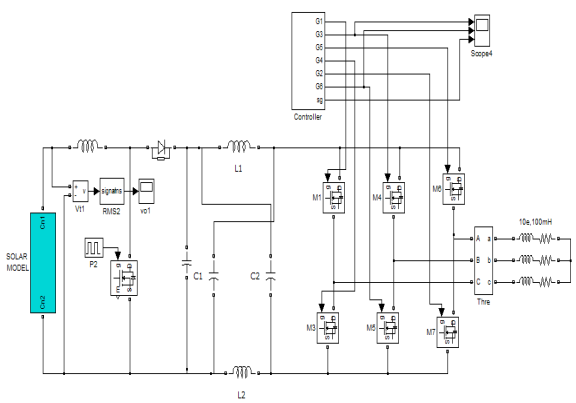

Figure10. Impedance-source inverter using PV cell

Output voltage of PV panel near about 25V shown in figure 11 is boosted twice the PV panel output and is shown in figure12. Regulated and boosted output voltage of boost converter is converted in to three phase AC using impedance-source inverter. The output voltage and output current of impedance source inverter are shown in figures 13 and14 respectively. Through the photovoltaic based impedance-source inverter system the simulated value of power in watts is 31 which is to some extent higher than the traditional voltage source inverter using solar cell.

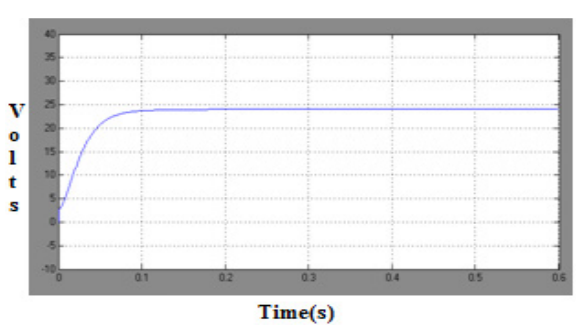

Figure11. Output voltage of solar cell

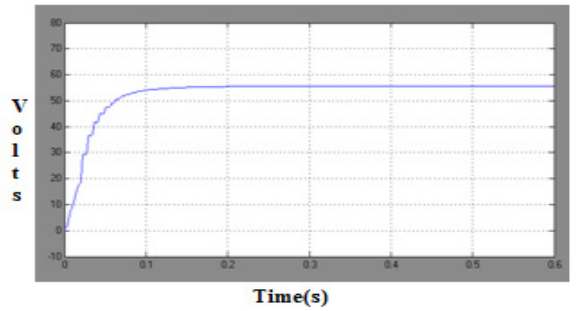

Figure12.Output voltage of Boost converter

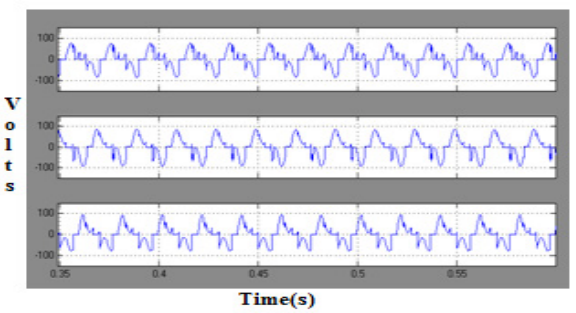

Figure13. Output volatge of inverter

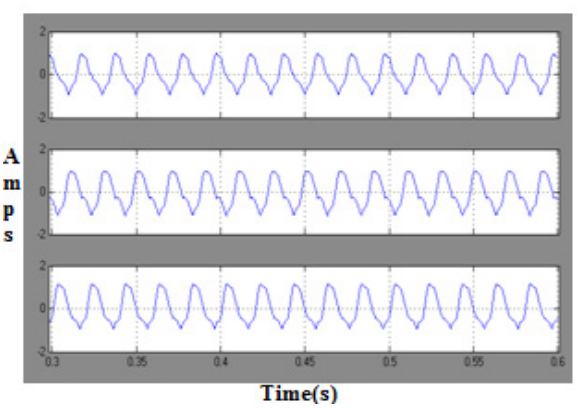

Figure14.Output current of inverter

V. Conclusion

A comparison of traditional voltage source and Z-source inverter using solar cell has been executed. The comparison results show that the Z-source inverter can increase power level over traditional inverter. Thus, Z-source inverter increase output power greatly. With these results the Z-source inverter offers consistency since shoot through can no longer destroy the inverter. The existing traditional inverter suffers the shoot through consistency problem. In summary, Z-source inverter is very promising for photovoltaic system. This work explains a scheme implemented on photovoltaic system with impedance-source inverter to extract maximum energy from renewable energy resources. Simulation models of photovoltaic system are developed and the output power obtained under different cases and conditions are compared. The future scope of this work is to realize a hardware model of the system.

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