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Design and Implementation of Gamma Z-source Inverter for Solar Power Applications Using Fuzzy Control

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ABSTRACT

This paper focuses the solar power based gamma Z-Source Inverter (ZSI) for various solar power supply application. The concept of gamma z-source inverter can be applied to all dc-to-ac, ac-to-dc, ac-to-ac, and dc-to-dc power conversions. The gamma ZSI topology overcomes the limitations of conventional boost converter interfaced with Voltage Source Inverter (VSI) and current source inverter (CSI). By this new topology, solar power is utilized properly with fuzzy controller circuit. The proposed system can maintain the desired output voltage through proper switching of gamma Z-source inverter. Total harmonic distortion (THD) and Electromagnetic magnetic interference (EMI) noise can be reduced by the proposed topology with fuzzy logic controller.

1. INTRODUCTION

Now a day's focuses of the researchers have been applied for the renewable energy resources like solar photovoltaic module. The proposed gamma ZSI system fulfils the research gap in the fields of solar and fuel cell applications. Traditional voltage-source inverter (VSIs) are perform only step down voltages and having some limitations and problems. For Voltage source inverters AC output voltage cannot exceed the DC source voltage. So a DC-DC boost converter is placed before the VSIs for the application purpose. Alternatively, single-stage buck-boost inverter can be used like the Cuk, SEPIC and other similar DC-AC inverters. Secondly Dead time required to prevent the shoot-through of the upper and lower switching devices of each phase leg, it induces waveform distortion. Research in buck-boost inverter named as the Z-source inverter has grown rapidly with its modulation, dynamic control and sizing. It's application to motor devices, solar generation and electric vehicles using the same basic Z-source impedance network.

Due to the environmental impact sometimes the available numbers of solar modules are limited. By adjusting the boost factor one can obtain maximum power output in accordance with solar power. This paper is organized as follows. Section II shows the introduction of proposed gamma ZSI. Simulation of solar PV module and gamma source inverter is addressed in Section III.The proposed network used a voltage boosting by transformer and a capacitor. Their gain is raised by lowering their transformer turn's ratio, rather than increasing it. So far, this feature has not been matched by other Z-source circuits. Performance of the proposed circuits has been tested in the experiment. The introduction of the paper should explain the nature of the problem, previous work, purpose, and the contribution of the paper. The contents of each section may be provided to understand easily about the paper.

2. Γ-Z SOURCE INVERTER

The Trans Z source inverter with source placed in series diode is a voltage Γ-Z type source inverter are proposed in this letter. They use a unique Γ–shaped impedance network for boosting their output voltage in

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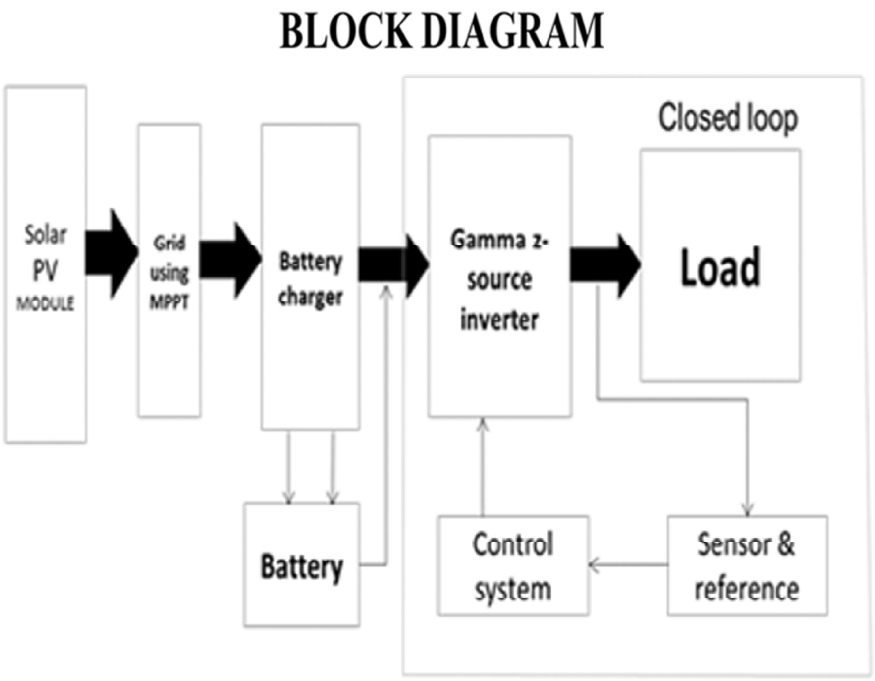

Figure 1: Block diagram of solar powered gamma ZSI system

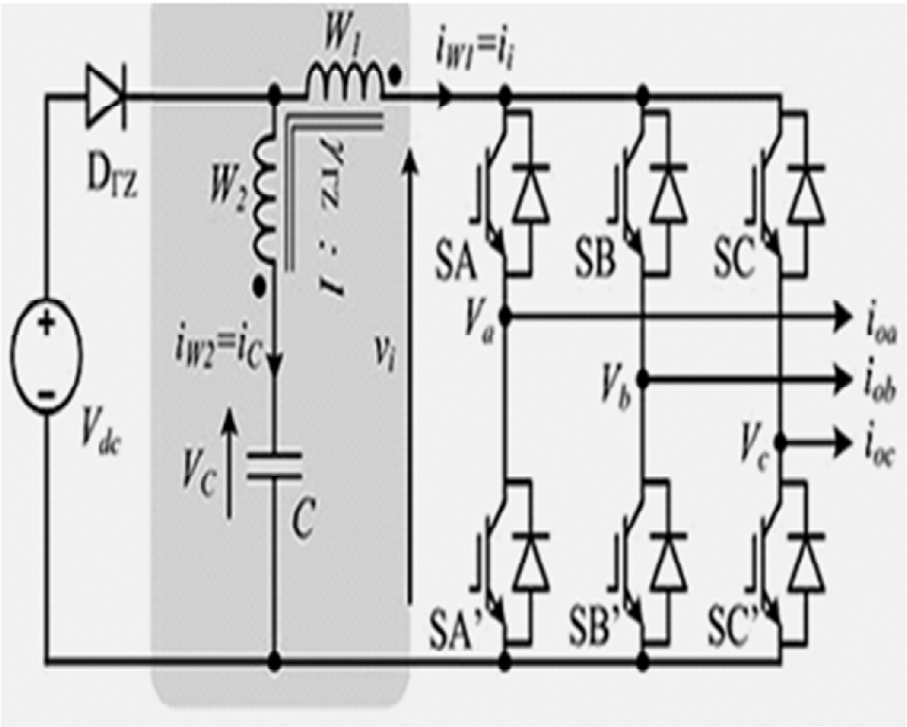

Figure 2: Γ-Z source Inverter

addition to their usual voltage buck behaviour. The proposed inverters use lesser components and a coupled transformer for producing the high-gain and modulation ratio simultaneously. The gain can be tuned by varying the turn's ratio of the transformer within the narrow range of 1:2. This leads to lesser winding turns for high gain, as compared to other related topologies. Γ-Z source network is symmetric network and pole zero diagram is same as per the mathematical calculation is proved.

$$V_a = \frac{V_1}{LCS^2 + 1} \tag{1}$$

$$V_b = \frac{V_1\left(LCS^2\right)}{LCS^2+1} \tag{2}$$

$$V_2 = V_a - V_b$$

$$V_2 = \frac{V_1}{LCS^2+1}\left(1-LCS^2\right)$$

$$\frac{V_2}{V_1} = \frac{\left(S^2-\omega^2\right)}{\left(S^2+\omega^2\right)}$$

$$= \frac{(S+\omega)(S-\omega)}{(S+j\omega)(S-j\omega)} \tag{3}$$

To redesign the Z source network into Γ-Z Source network in this proposed network the two inductance value is obtained as 0.002mH and capacitance value is obtained as 3000μF from the reference paper of Z source inverter by F.Z Peng the formula obtained as

$$L = \frac{V_i^{\delta}}{f\,\Delta I} \tag{4}$$

$$C = \frac{\delta}{2\,fR'} \tag{5}$$

In the proposed system the loss of inductance value obtained as 1.37watt, the loss of capacitance value is obtained as 1.37watt and the overall efficiency of Γ-Z network is 79.5%.

The advantages of system which reduced voltage spikes and current spikes during conversion of Γ-Z source filter into three phase inverter circuit and voltage can be boosted by Γ-Z source filter. The application of system is used to control the speed of induction motor and synchronous motor.

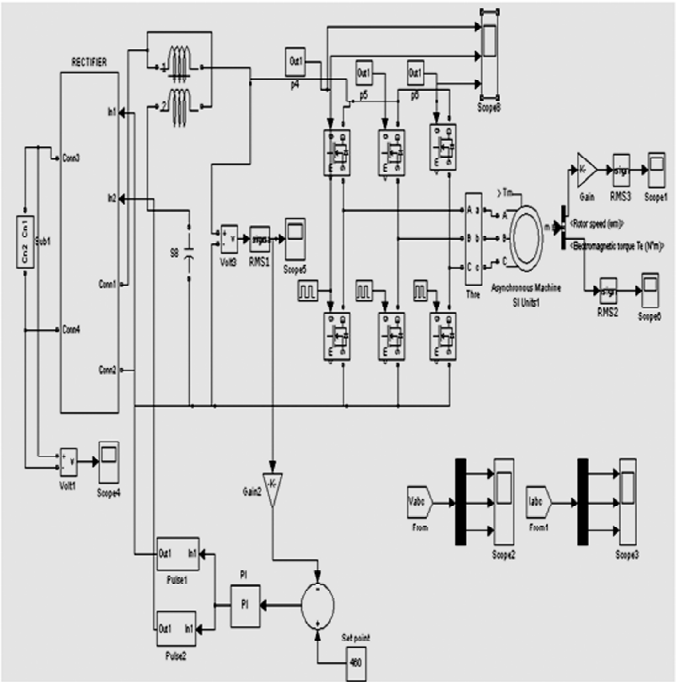

Figure 3: Γ-Z Source Network of Closed Loop System

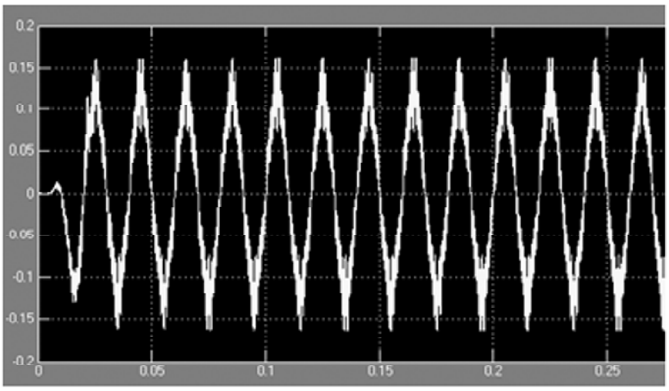

Figure 4: Proposed system Output Voltage in Closed Loop

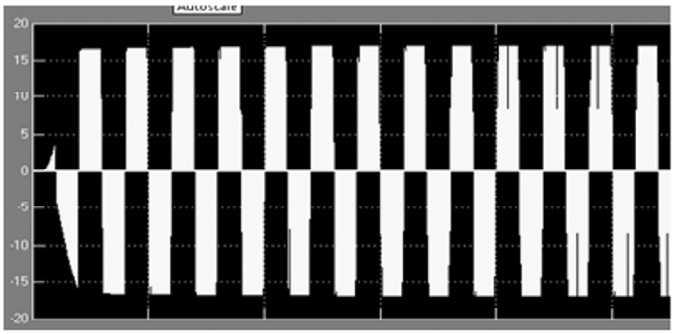

Figure 5: Output voltage of asynchronous Motor in Closed Loop System

The design of the proposed gamma ZSI system is given below

III. PROPOSED SYSTEM SIMULATION & RESULT

The PV cell is connected with battery using MPPT technique. The gamma source inverter can be connected with the DC source of battery and getting output of AC.The alternating current source again can be boost up for our solar power applications by using fuzzy controlling technique.

The simplest equivalent circuit of a solar cell is a current source in anti-parallel with a diode. When exposed to light, a dc current is generated. The generated current varies linearly with the solar irradiance. The standard equivalent circuit of the PV cell is shown in the above figure

Table. I. implies the input and output parameter analysis for conventional and proposed power converter system. In the power converter system the battery discharge is of about 28A. The proposed system is more

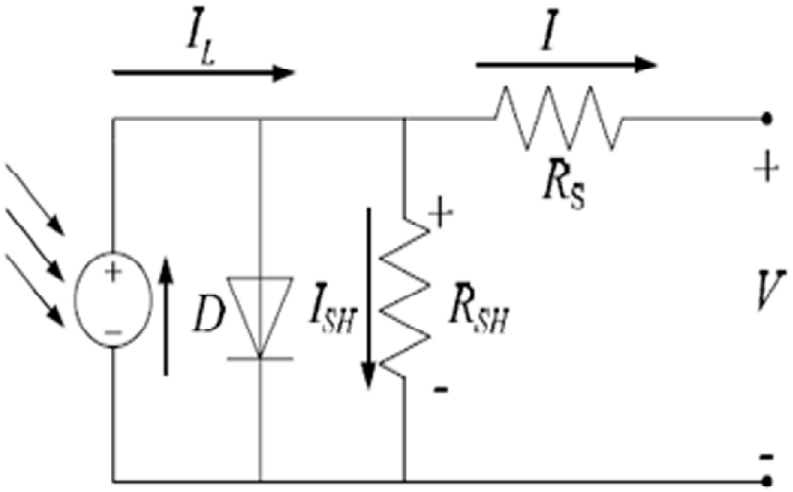

Figure 6: Equivalent Circuit of a PV Cell

Table 1
Input And Output Parameter Comparison

Power converter topology	*Solar panel output voltage in volt*	*Solar panel output current in amp*	*Output voltage (AC) in load*	*Output current in load*
Boost Chopper	12	8	220	25
Maximum boost ZSI	12	8	240	28
Gamma ZSI	12	8	320	30

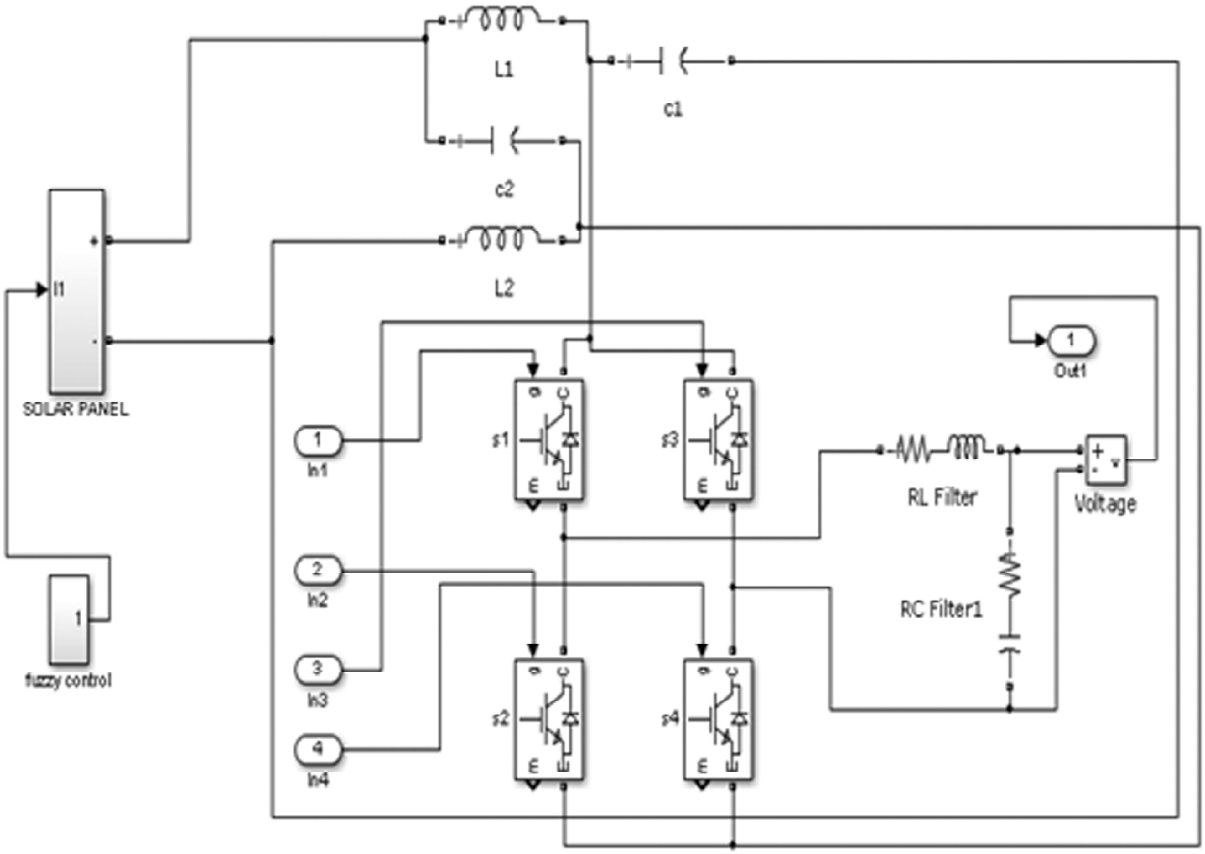

Figure 7: Γ-Z Source Network for PV cell

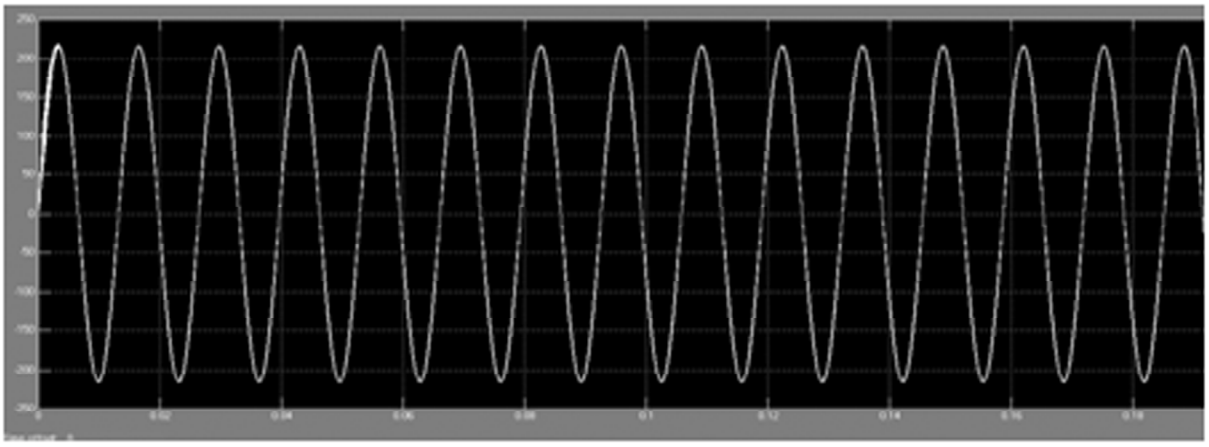

Figure 8: Output Voltage of Γ-Z Source Network for PV cell

convenient for utilizing the renewable resources compared to boost converter system hence utilizing less controller circuit.

4. CONCLUSION

Thus the above proposed system it known that the output voltage is improved by using Γ-Z Source inverter. when the conventional system is compared with the proposed system, it neglected shoot-through effect towards the conversion technique without distortion. Here with the simulation results from the mat lab environment and mathematical calculation of inductor and capacitor clearly discussed for the proposed system. Additionally the closed loop results of output voltage for PV cell using fuzzy controller present in this paper.

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