iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** VI **Month of publication:** June 2018

DOI: http://doi.org/10.22214/ijraset.2018.6154

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue VI, June 2018- Available at www.ijraset.com

Hybrid Pulsewidth Modulation Three Phase Switched Inductor Quazi Z-Source Grid-Tie Photovoltaic Power System

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Abstract*: Recent years, the increase in consumption of electrical energy results in development of grid applications. The single stage power conversion inverters such as Z-source inverter, Quasi Z-source inverter etc gains more importance due to advantages such as absence of dead time, robustness to input DC line variations. In this work, a Hybrid pulsewidth modulated three phase switched inductor Quasi Z-source Inverter (HPMSI) is proposed. Further, the proposed HPMSI quasi Z-source inverter is utilized for grid-tie photovoltaic (PV) power system application. The simulation work of the proposed HPMSI quasi Z-source inverter has been carried out using MATLAB/SIMULINK software. Results demonstrate that the proposed converter is capable of converting the applied input DC voltage from PV system to equivalent output grid AC voltage. Further, the parameters such as three phase output voltages, three phase output currents, Grid current, dc link current, real and reactive power of HPMSI quasi Z-source inverter is presented.

***Keywords*: Hybrid pulsewidth modulation, photovoltaic power system; quazi Z-source inverter, grid-tie, switched inductor**

I. INTRODUCTION

In recent years, large amount of non-renewable energy has been used which results in global warming and higher air pollution. Further, there is always a need for renewable energy conversion systems such as solar energy, wind energy, tidal energy conversion systems [1].

In general, the availability of solar energy is abundant and with the help of photovoltaic (PV) cells, solar energy can be converted to electricity. The potential of a single PV panel (or) cell is very less and for further utilization these potentials can be boosted with the help of high step up DC-DC converters.

The high step up DC-DC converter acts as an interfacing medium between the input source and several domestic and commercial devices such as lamp ballasts, industrial drives, automobile drives, uninterrupted power supplies etc.

Many isolated and non-isolated high step up converters have been proposed by researchers in the past decade [2 – 5]. By considering isolated high step DC-DC converters, it ensures high safety standards (galvanic isolation) with high voltage gain.

In industries, the simple machines such as centrifugal pumps, blowers, vacuum cleaners etc can be driven by single phase induction motor.

The electrical energy supplied to these systems is utilized from grid. In case of electricity generated from alternative energy applied to these systems save the consumption of energy at utility grid.

Generally, the DC-DC converters along with the inverters for the conversion of input solar energy to output AC is utilized. It is a two stage conversion process results in drawbacks such as more losses etc. The quasi-Z-source inverter (qZSI) has attracted interests in PV applications because of single-stage power conversion, no dead time between switches of one bridge leg, and ability of handling wide dc voltage variations [6], [7].

Moreover, the single-phase qZSI can operate as a module to form cascaded inverter systems [8]-[11] or as independent inverter systems [11]-[13]. However, the second-order harmonic (2ω) pulsating power appears in the single-phase qZSI power module's dc link and transfers to qZS capacitors and qZS inductors, no exception to PV panels, which introduces low-order harmonics into the ac output and may shorten the lifetime of PV panels [12].

To limit the 2ω voltages and currents within tolerant ranges, large qZS capacitance and inductance are required when using the traditional carrier pulsewidth modulation (PWM) of the single-phase qZSI [11]-[13]. Bulky qZS capacitors and inductors will not only increase volume and cost, but also degrade system efficiency and reliability.

In this paper, a Hybrid pulsewidth modulated three phase switched inductor Quasi Z-source Inverter (HPMSI) for grid-tie photovoltaic (PV) power system is proposed.

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II. METHODOLOGY

Figure 1 shows the proposed HPMSI quasi Z-source Inverter. It consists of quasi Z-source network connected with three phase inverter bridge. The quasi Z-source network consists of inductors (L1, L2), capacitors (C1, C2) and one diode. In general, the quasi Z-source inverters or Z-source inverters not only converts input DC power to AC power but also it boosts or step up the input voltage to the desired output voltage range. The HPMSI quasi Z-source Inverter is sourced by photovoltaic power system. Further, the HPMSI quasi Z-source Inverter is fed by three phase RLC load. One LC filter is utilized to tune the output of the HPMSI quasi Z-source Inverter to a near sinusoidal wave. Also, the HPMSI quasi Z-source Inverter is connected to the utility grid and the energy demand at the grid side is varied by varying the load connected to the utility grid and the versatility of the proposed HPMSI quasi Z-source Inverter is evaluated.

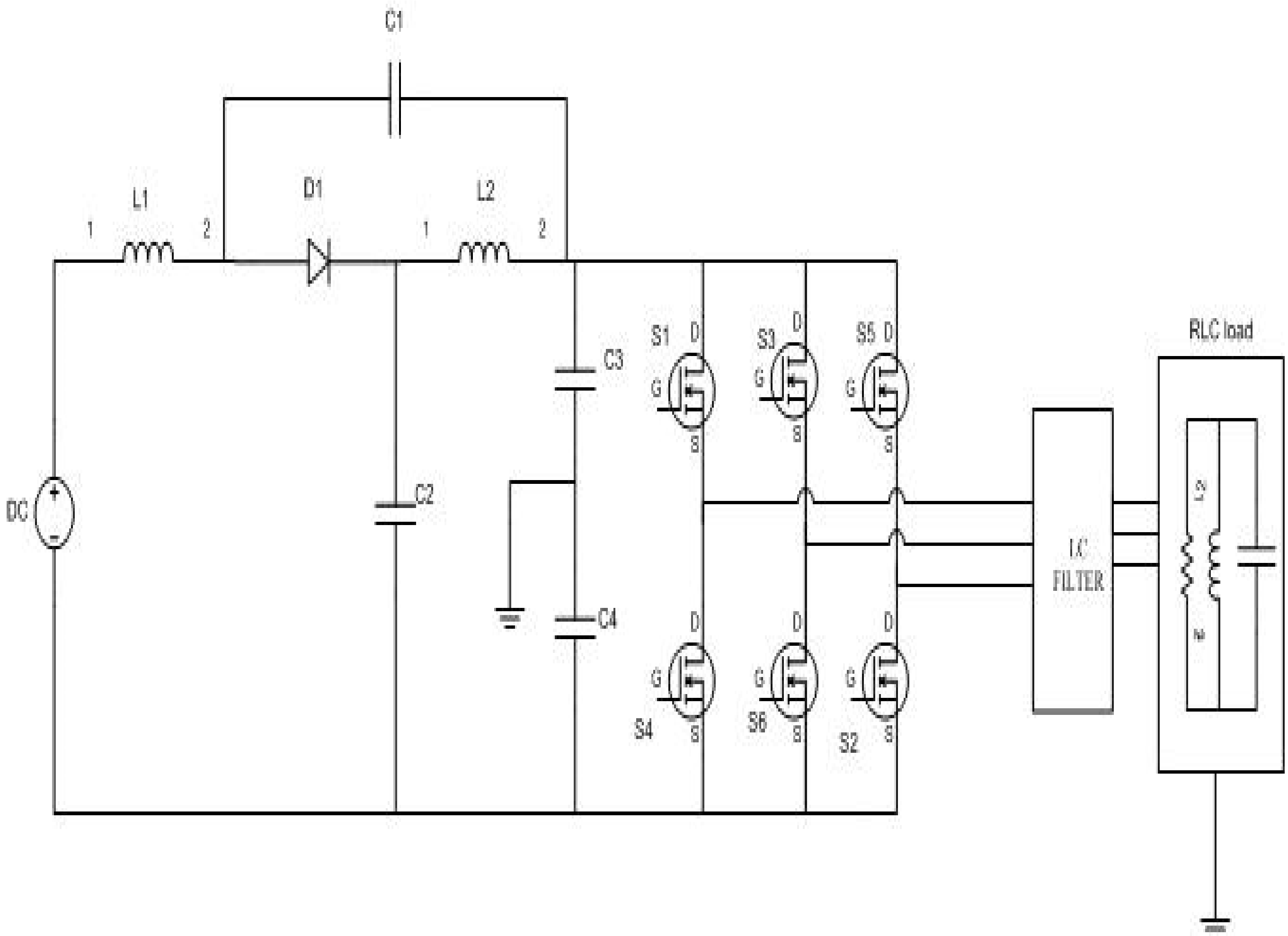

Figure 1 The proposed HPMSI quasi Z-source Inverter

Table 1 presents the parameter values of the proposed HPMSI quasi Z-source Inverter. The voltage step up can be obtained by selecting suitable inductor and capacitor values of the quasi Z-source network.

TABLE I
THE PARAMETERS OF THE PROPOSED HPMSI QUASI Z-SOURCE INVERTER

S.No.	Components	Range/ Value
1	Inductor (L1, L2)	600Uh, 1mH
2	Capacitor (C1, C2, C3, C4)	1000uF, 2200uF, 2200uF, 2200uF
3	LC Filter	2mH, 1000uF
4	RLC Load	1kW

III.RESULTS AND DISCUSSION

Figure 2 shows the output phase-phase voltage and filtered phase-phase voltage of the proposed HPMSI quasi Z-source Inverter. It is observed that the output of the HPMSI quasi Z-source inverter is a two level (positive and negative) output waveform. Further, it is seen that the LC filter at the output side of the HPMSI quasi Z-source inverter tunes the output voltage to a pure sine wave.

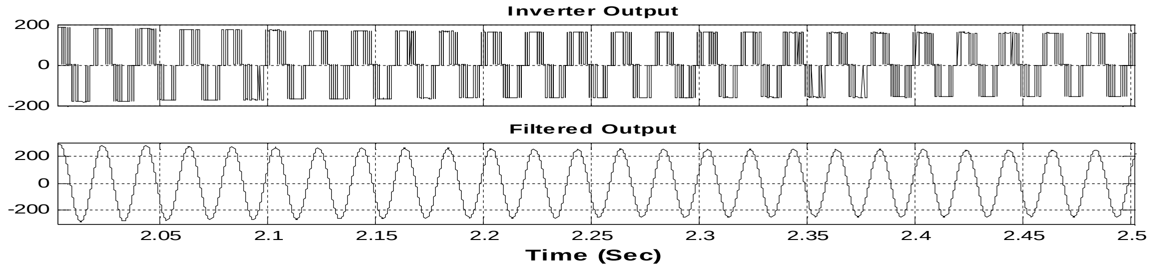

Figure 2 The output phase-phase voltage and filtered phase-phase voltage of the proposed HPMSI quasi Z-source Inverter

Figure 3 shows the three phase output voltage and three phase output current of the proposed HPMSI quasi Z-source Inverter. The 1kw RLC load is connected at the output side of the HPMSI quasi Z-source inverter. The corresponding three phase voltage and three phase current consumption of the RLC load can be observed from the figure 3. Since, the HPMSI quasi Z-source inverter works on single stage conversion principle, it is seen that the output voltage of the proposed HPMSI quasi Z-source inverter is in standard range.

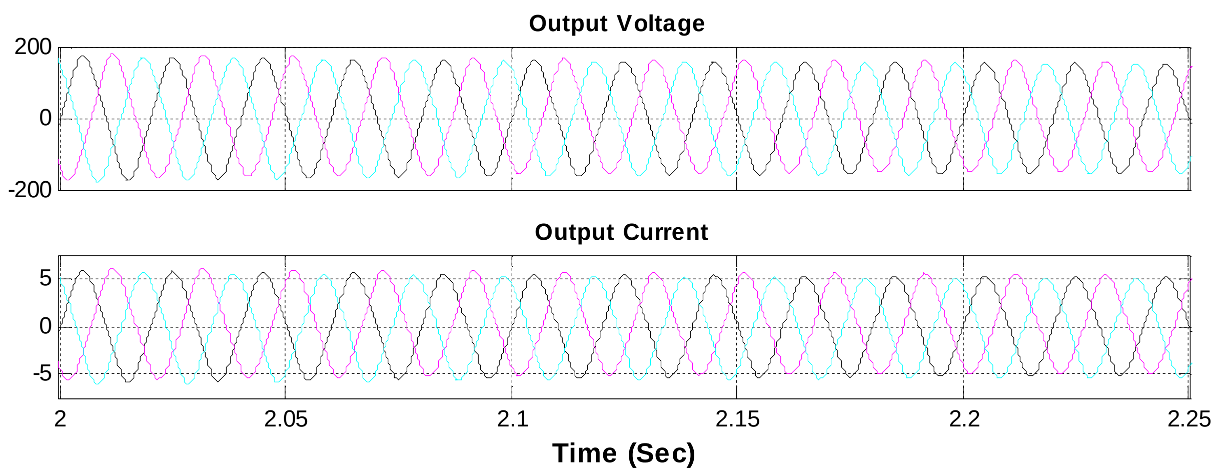

Figure 3 The output voltage and output current of the proposed HPMSI quasi Z-source Inverter

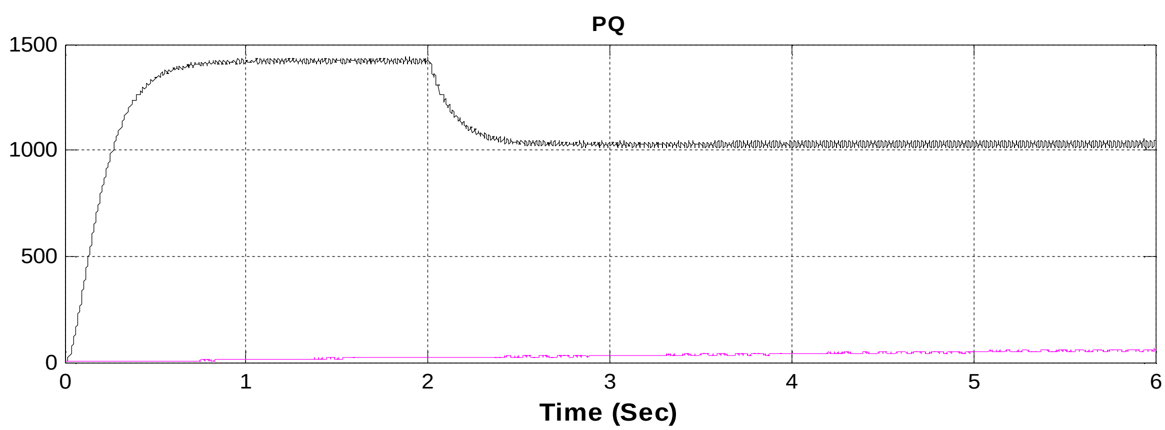

Figure 4 Three-phase instantaneous active and reactive power

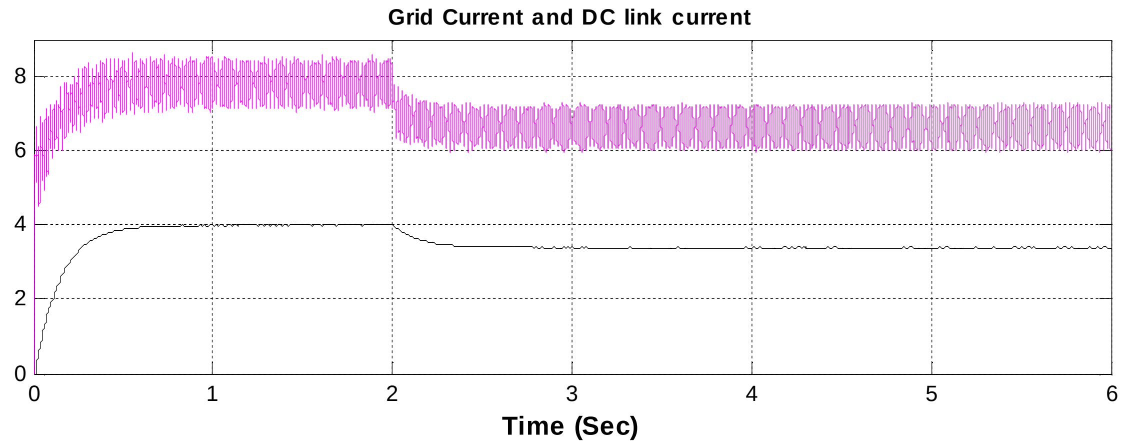

Figure 5 Grid Current and DC link current

Figure 4 shows the three-phase instantaneous active and reactive power at the utility grid. Also, the proposed HPMSI quasi Z-source inverter is connected to the utility grid which converts the solar energy and injects it on to an utility grid. The RLC load is connected to the utility grid while the HPMSI quasi Z-source inverter also feeds the grid according to the load demand. Figure 5 shows the grid current and DC link current.

IV. CONCLUSIONS

In this work, a Hybrid pulsewidth modulated three phase switched inductor Quasi Z-source Inverter (HPMSI) was developed. Further, the proposed HPMSI quasi Z-source inverter is sourced by the Photovoltaic power system and the output power is fed to the utility grid. The simulation work of the proposed HPMSI quasi Z-source inverter was presented. Results demonstrate that the proposed converter compensates the energy demand at the utility grid and the corresponding three phase active and reactive power for the connected RLC load is presented. Further, the output of the HPMSI quasi Z-source inverter shows that the developed system is highly suitable for renewable energy based power generation system.

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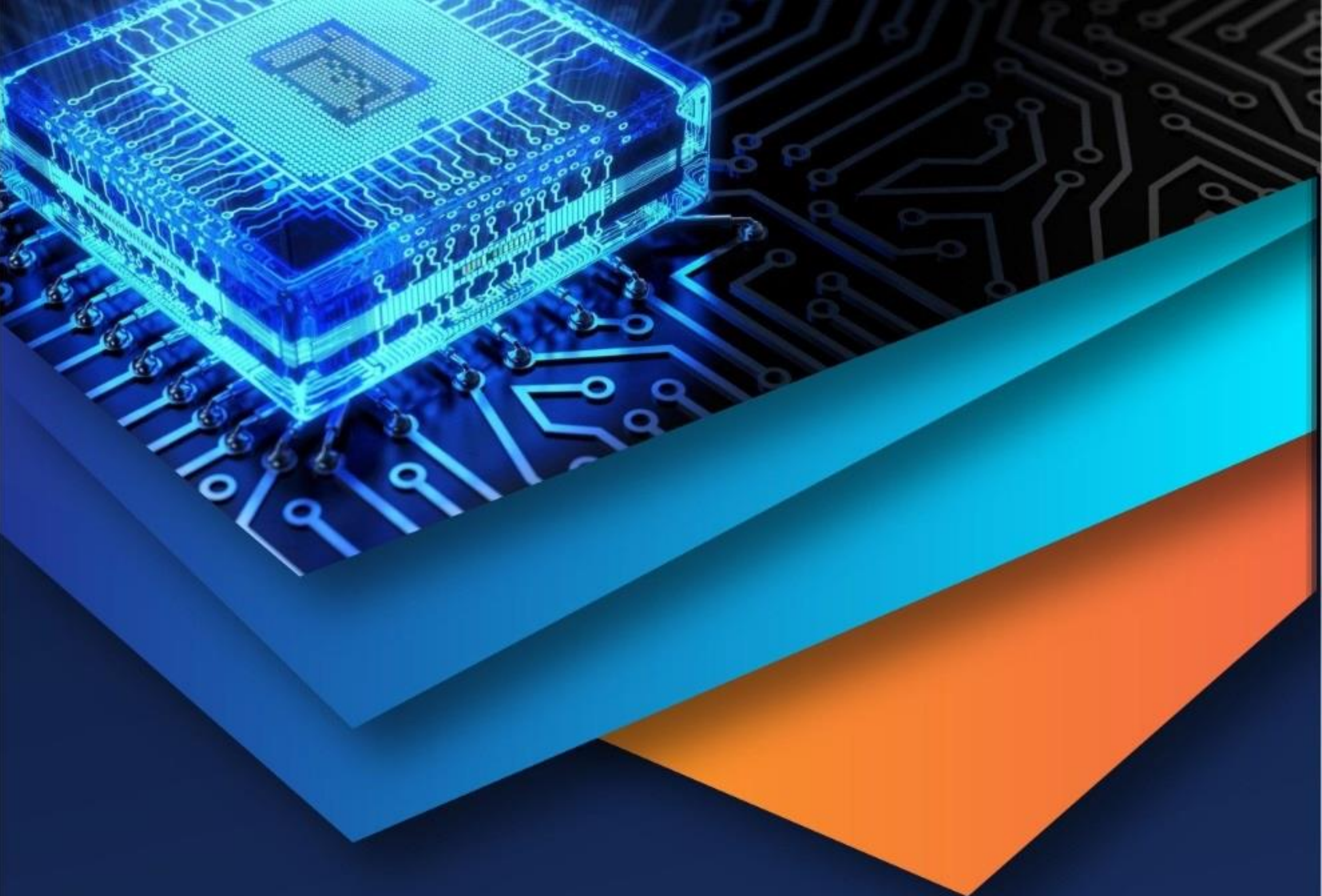

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