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Soft Switched Transformer–Less Single Phase Inverter for Photovoltaic Systems

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Abstract : The inverters for photovoltaic systems are important, since the DC power has to be converted to alternating supply to feed to AC loads. The power conversion stage includes an inverter and a transformer. If low frequency transformer is used, it provides galvanic isolation, but the total cost and size of the system will also increase. These issues can be addressed by using high frequency transformer. Even then the overall efficiency of the system is less due to many conversion stages. Transformer-less inverter is one solution to overcome all the foresaid problems. Single stage DC-AC converter with zero voltage(ZVS) and zero current switching (ZCS) is more compact and energy efficient. Therefore a transformer-less DC-AC single phase inverter is presented in this paper. The converter performance, switching waveforms are simulated using PSIM and are presented in the manuscript. The soft switching of the converter is experimentally validated.

Keywords : Transformer-less single stage DC-AC inverter, Zero voltage switching, Zero current switching, Inverter for photovoltaic applications

1. INTRODUCTION

The solar power is abundantly available throughout the universe. Making use of this energy will reduce the consumption of fossil fuels. Solar energy is clean and its conversion to electrical energy will not have any harm full effect the nature. Efficient converters are needed to inject the solar power to the main grid. The selection and design of inverter for photovoltaic applications offers greater challenge in the integration side. As it is photovoltaic systems are less efficient, hence there is a greater need to have energy efficient inverters to reduce the payback period. Kjaer etal in [1] presented various inverter topologies, evaluated their life time against the demands, ratings of various components and cost. The various inverter families, number of processing stages, transformers and types of interconnections were compared for both single and multiple PV modules by several researchers [1-4]. Single phase inverters are used in domestic distribution side. For domestic applications, inverters without galvanic isolation can be used [5].

Transformer-less, galvanically connected grid tied inverters have better efficiency. They are compact, lighter in weight and also cost effective [6-8]. The major challenge in such inverters is common mode leakage current [9]. To minimize leakage current, a topology consisting of H-bridge with diode clamping was proposed in [10]. In that topology, the short circuited output voltage was brought down to 50% of DC input voltage. A novel positive–negative neutral point clamped multilevel inverter was proposed in [11] for eliminating the common mode voltage and best conversion efficiency. High frequency inverters exhibit more switching losses which can be minimized by soft switching of inverter switches [12]. Simulation works for the proposed system was carried [13]. This paper proposes a transformer-less, soft switched

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inverter for photovoltaic applications. The converter configuration is described in section II. Simulation results are analysed in section II. Experimental results are given in section IV. The work is concluded in section V.

2. CONVERTER DESCRIPTION

Figure 1 shows the inverter configuration. Two H-bridge inverters with resonating elements are used. The converter specifications are given in Table 1.

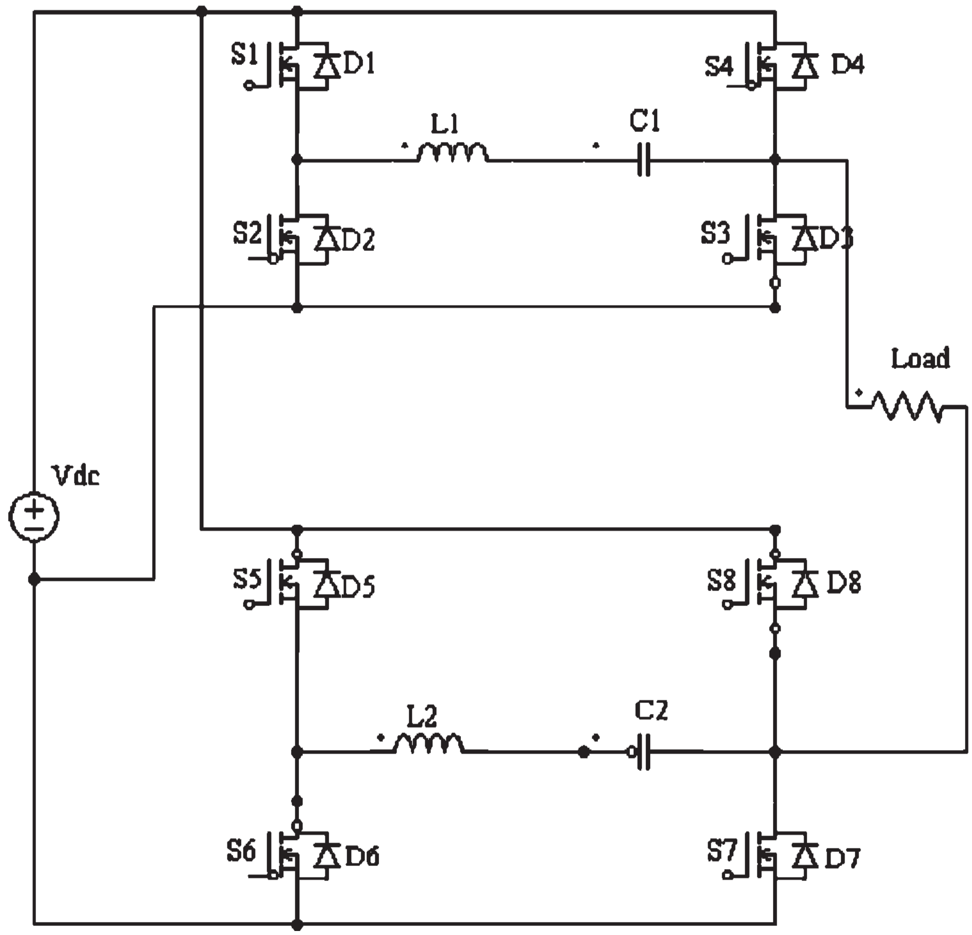

Figure 1: Transformer-less H-bridge Inverter Topology

Upper H-bridge contains L1 and C1 as resonating elements whose values are given in Table 1 and lower H-bridge contains resonating elements L2 and C2. The circuit is designed in such a way that there is zero voltage turn-on of all the switches and zero current turn-off.

Table 1
Specifications

Parameters/Components	*Value*
Input Voltage	10V
L1	20μH
L2	20μH
C1	100μF
C2	100μF
Switching Frequency	15kHz
Rload	200Ω

3. SIMULATION RESULTS

The paper focuses on soft-switching. Therefore the gating pulses, switch current and voltage waveforms for switches S1-S8 are shown from Figure 2-9 respectively.

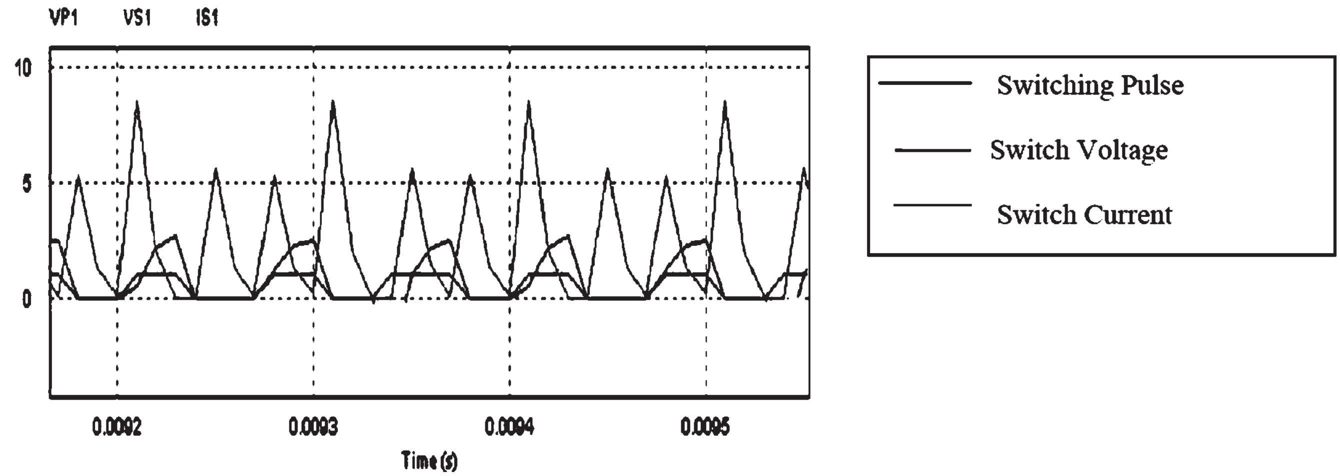

Figure 2: Switching Pulse, Voltage and Current of Switch S1

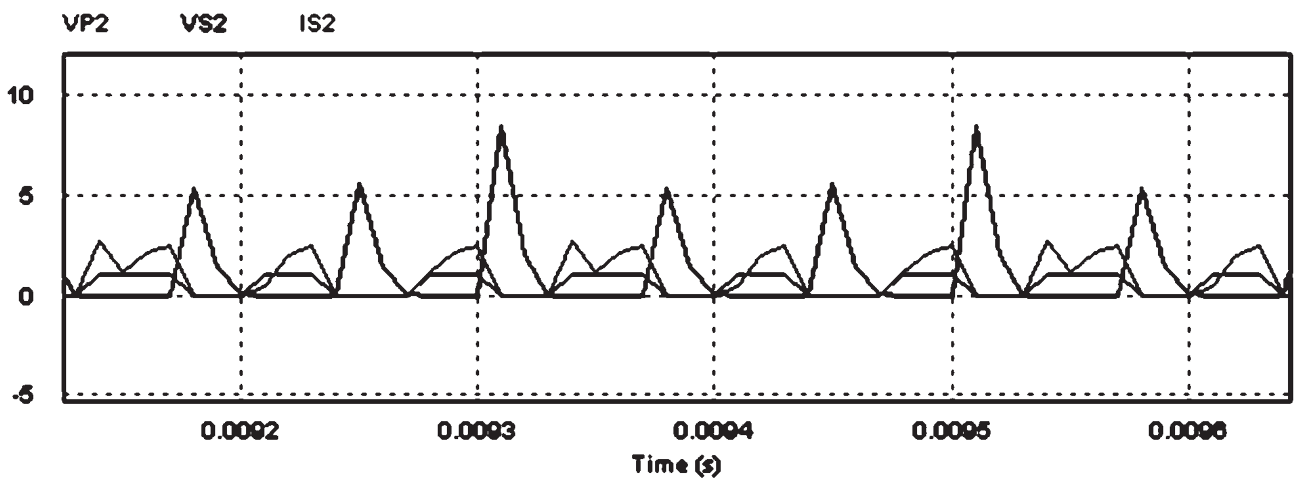

Figure 3: Switching Pulse, Voltage and Current of Switch S2

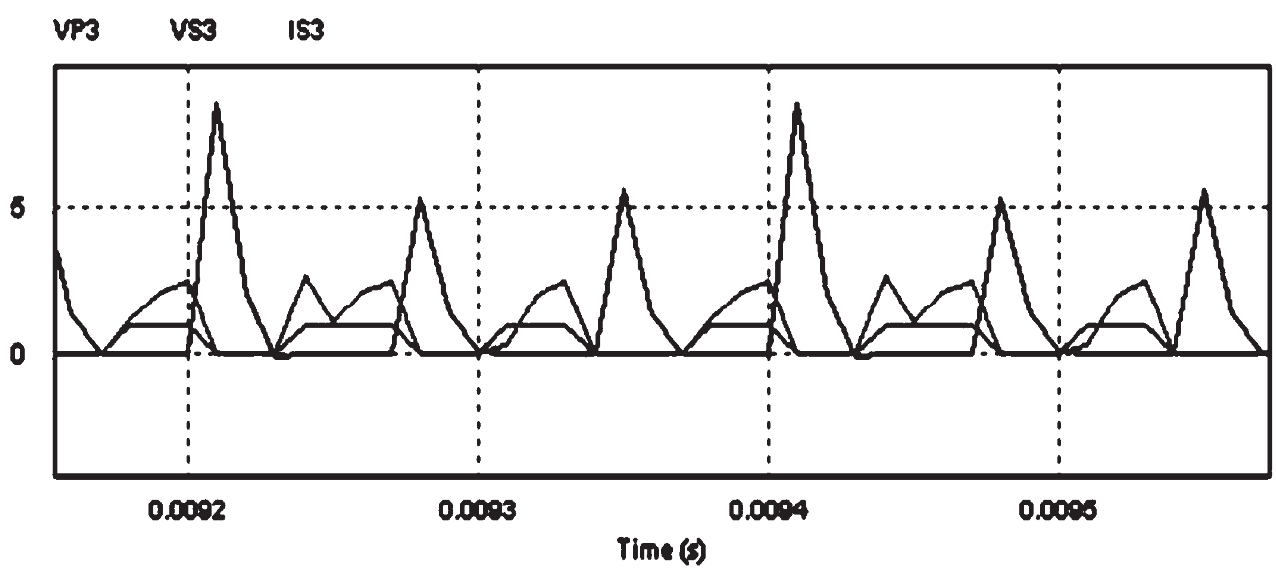

Figure 4: Switching Pulse, Voltage and Current of Switch S3

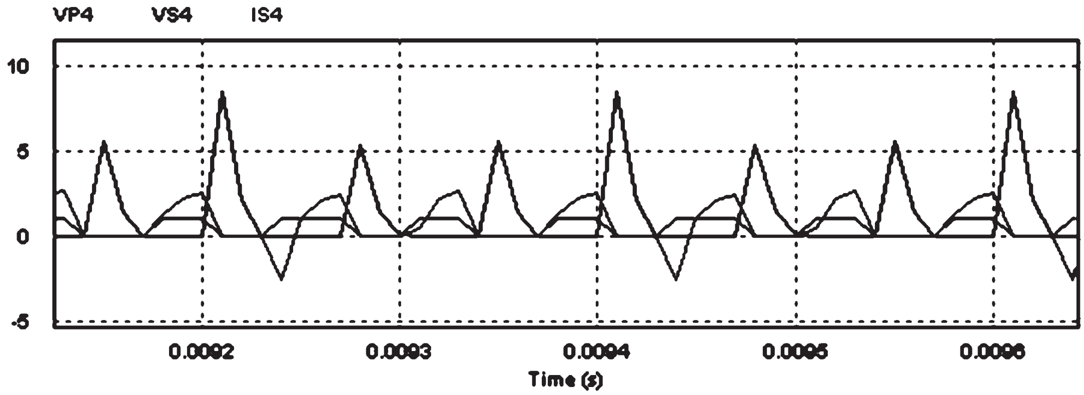

Figure 5: Switching Pulse, Voltage and Current of Switch S4

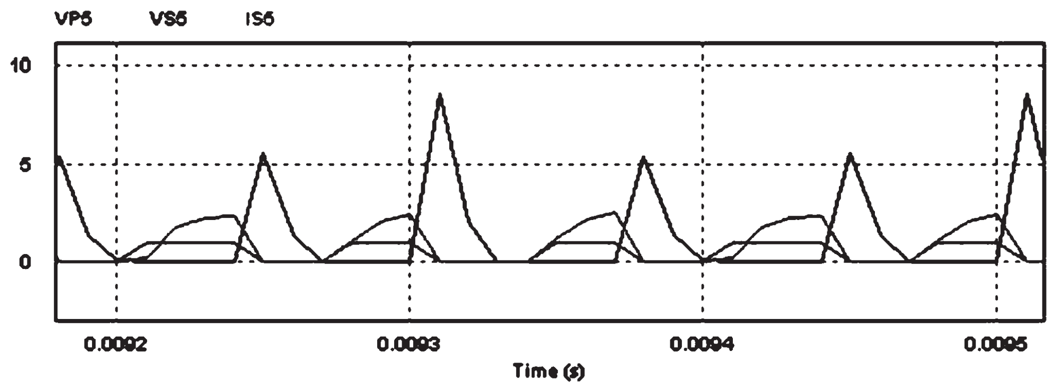

Figure 6: Switching Pulse, Voltage and Current of Switch S5

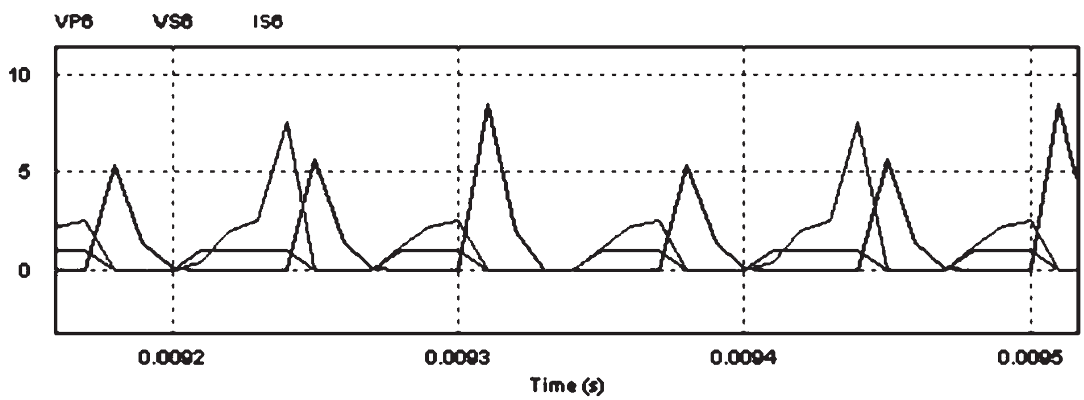

Figure 7: Switching Pulse, Voltage and Current of Switch S6

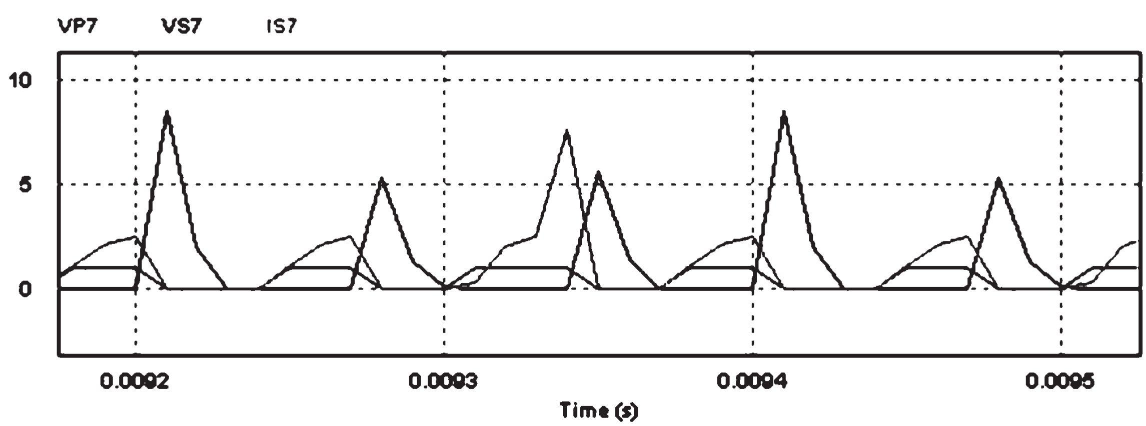

Figure 8: Switching Pulse, Voltage and Current of Switch S7

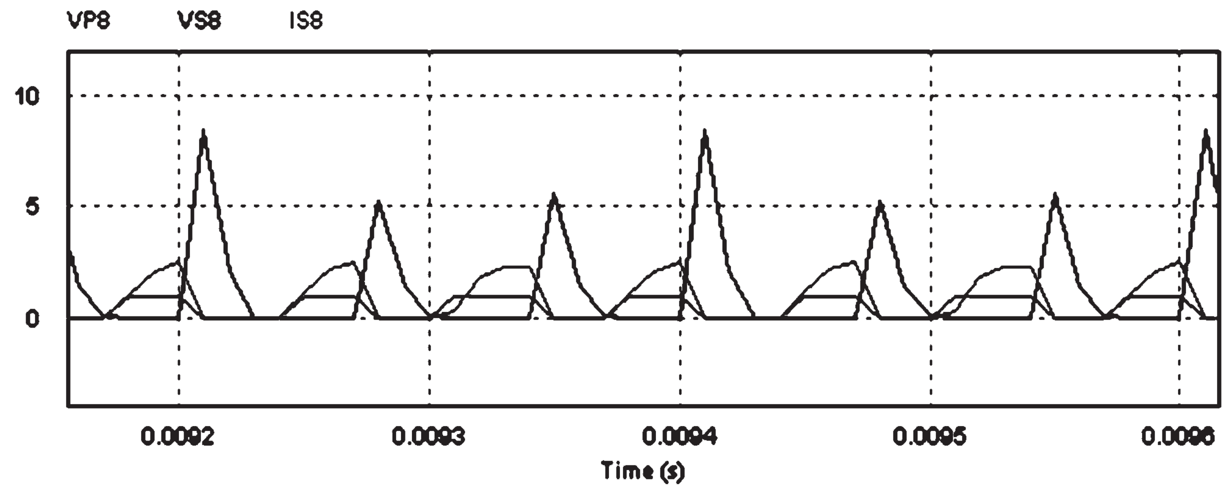

Figure 9: Switching Pulse, Voltage and Current of Switch S8

From Figures 2-9 it was observed that across all the switches at the instant of turn-on switches the voltage across them is zero. Hence turn on loss will be zero. It was also observed that during turn-off, current through switches was zero. Therefore the turn-off power losses were alleviated.

4. EXPERIMENTAL RESULTS

The experimental set up is shown in Figure 10. The input voltage trace is shown in Figure 11. The input voltage is shown in Figure 12. The switching pulses for the inverter and driver are shown in Figure 13 and Figure 14 respectively. The output of the inverter is shown in Figure 15.

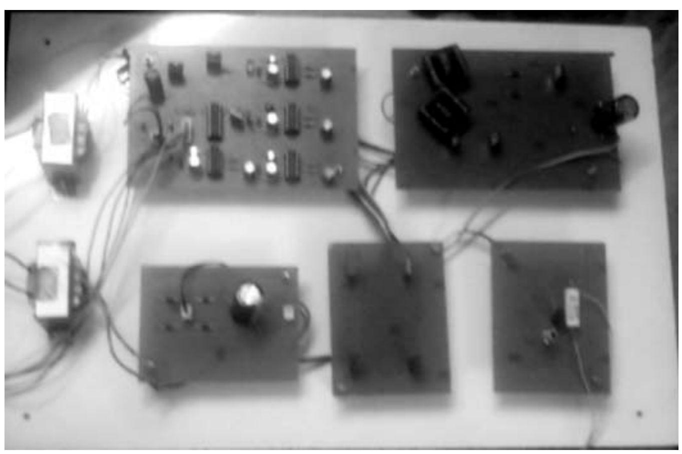

Figure 10: Experimental setup

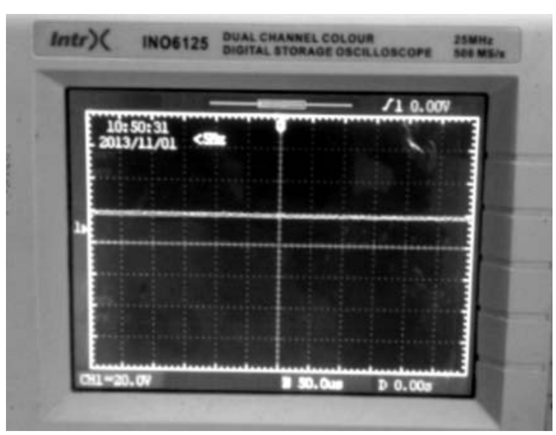

Figure 11: Input Voltage

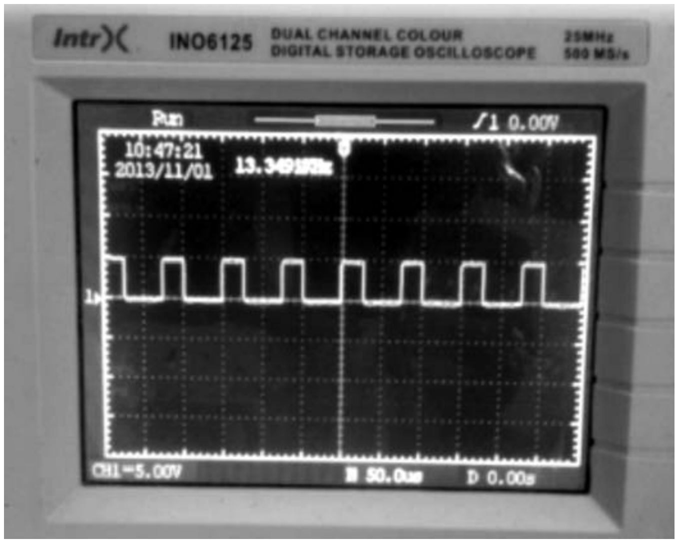

Figure 12: Switching pulse for inverter

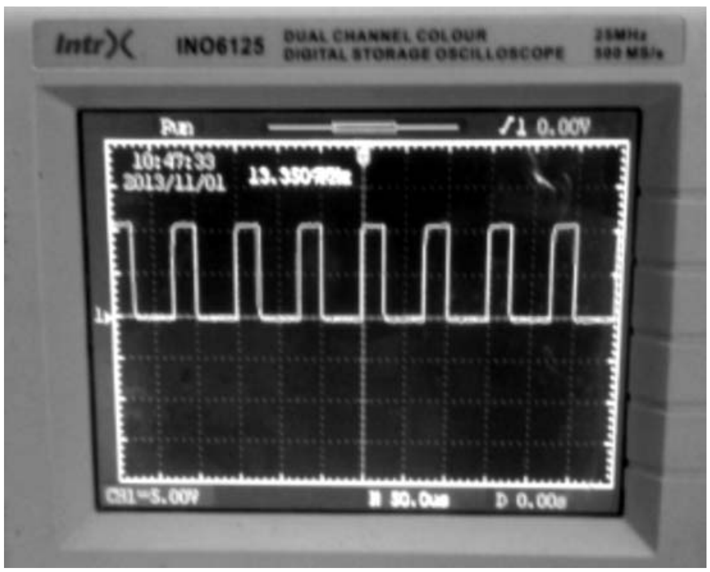

Figure 13: Switching pulse for driver output

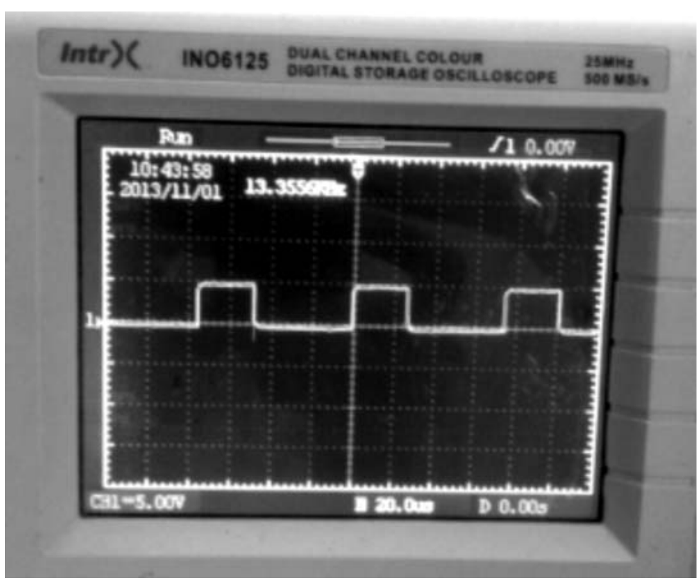

Figure 14: Wwitching pulse for driver output

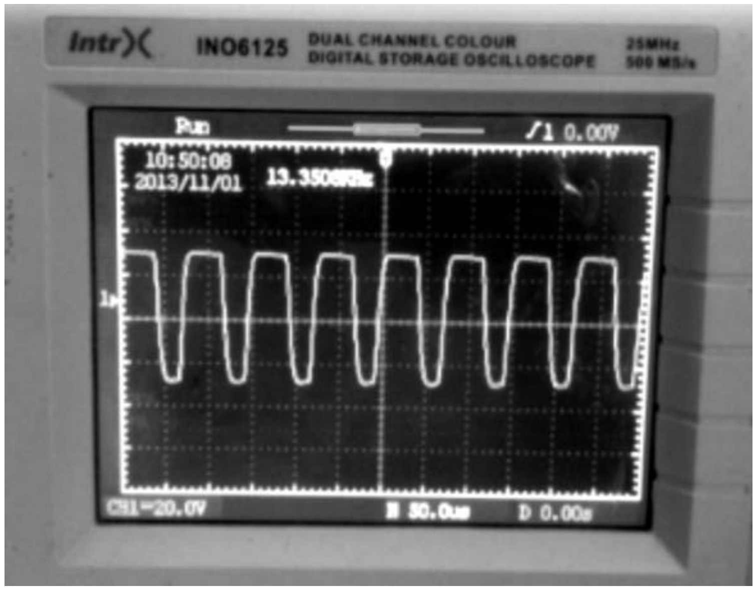

Figure 15: Inverter output voltage

5. CONCLUSION

A novel inverter topology was proposed. From simulation results it is observed that there is ZVS and ZCS of all the switches. The converter performance is good comparatively with the conventional methods. Further the work can be extended to build continuous load current. Single stage DC-AC converter with zero voltage(ZVS) and zero current switching (ZCS) is more compact and energy efficient. Therefore a transformer-less DC-AC single phase inverter is presented in this paper. The converter performance, switching waveforms were simulated using PSIM and are presented in the manuscript. The simulation results are experimentally validated.

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