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Modelling and Simulation of High Step up DC to AC Converter for Microsource Application

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ABSTRACT

This paper deals with modelling and simulation of high step up DC – AC converter with micro source at the input. The 15V DC is stepped up to 230V DC using high step up DC-DC Converter. This DC is converted into AC using a single phase inverter. The DC-AC converter system is modeled and simulated using the blocks of simulink and the results are presented in this paper.

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I. INTRODUCTION

Renewable energy is becoming increasingly important and prevalent in distribution systems, which provide different choices to electricity consumers whether they receive power from the main electricity source or in forming a micro source not only to fulfill their own demand but alternatively to be a power producer supplying a microgrid [1], [2]. A microgrid usually includes various microsources and loads, which operate as an independent and controllable system when they are either grid-connected or islanded, as well as when they can reliably connect or disconnect [2]. The microsource is classified either as a DC source or as a high frequency AC source [3]. These two microsource categories are comprised of diverse renewable energy applications, such as solar cell modules, fuel cell stacks, wind turbines, and reciprocating engines [4]. Fig.1 shows a regular schematic of a microgrid unit supplied by various microsources; the high step up converter is used to increase the output voltage of the microsource to 380V-400 V for the dc interface to the main electricity source through the DC-AC inverter [2],[4]. Both the single solar cell module and the fuel cell stack are essentially low voltage sources, and thus, a high step-up voltage gain dc-dc converter is required to regulate the voltage of the DC-DC interface.

Previous research on various converters for high step-up applications has included analyses of the switched-inductor and switched capacitor types [5], [6], [24], [25], the boost type integrating with the switched-capacitor technique [7],[25], the voltage-lift type [8],[9], the capacitor –diode voltage multiplier type [10], and the transformerless dc-dc converters [11],[23]. In these converters the voltage gain is not enough to convert to a suitable ac source as a model microsource [1], in case of extremely high voltage gain is required, to using series connection of converter is able to reach much higher voltage gain. As known, the efficiency and voltage gain of dc-dc boost converter are restrained by either the parasitic effect of power switches or the reverse recovery issue of diodes. In addition, the equivalent series resistance (ESR) of capacitor and the parasitic resistances of inductor are also affecting overall efficiency [5]-[26]. Although an alternative solution is the DC-DC fly back converter along with some advantages such as simple structure, easy control, and cost effective, the energy of leakage inductor of the transformer leads to low efficiency and high voltage stress across the active switch. To employ an active clamp technique not only to recycle the leakage inductor energy of the transformer but to constrain the voltage stress is the crossed active switch [12]-[14], however, the tradeoff is of higher cost and a complex control circuit. Some converters effectively combined both boost and fly back converters as one or other different converter combinations are developed to carry out high step up voltage gain by using the coupled inductor technique [15]-[17]. Due to voltage gain has restricted by the voltage stress on the active switch, once the leakage inductor energy of the coupled inductor can be recycled that reduced the voltage stress on active switch, this leads to the coupled inductor and the voltage multiplier or voltage-lift techniques are successfully accomplished the goal of higher voltage gain [18]-[26].

This paper presents a cascaded high step-up DC-DC converter to increase the output voltage of the microsource to a proper voltage level for the dc interface through dc-ac inverter to the main electricity grid. The proposed converter is a quadratic boost converter with the coupled inductor in the second boost converter.

Fig.1.Basic schematic of microgrid consisted of microsources and power converters.

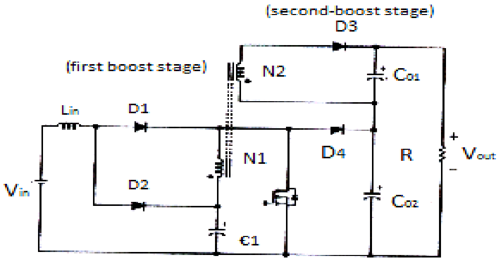

Fig.2.Circuit configuration of the proposed converter

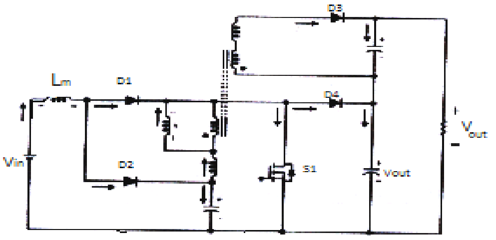

Fig.3.Simplified circuit model of the proposed converter.

The circuit diagram of the high step up converter is shown in Fig 2; the proposed circuit can be divided as a conventional boost converter and a boost-fly back converter [15]. These two segments are named first boost stage and second boost stage. The first boost stage is like a boost converter that includes an input inductor L_{in}, two diodes D_1 and D_2, and a pumping capacitor C_1. The second boost stage is a boost fly back converter that includes a dual winding coupled inductor T_1, two diodes D_3 and D_4, and two output capacitors C_{o1} and C_{o2}. In particular, these two stages are driven by a single switch S_1. The features of this converter are as follows:- 1) the quadratic boost converter in effectively extended to a voltage conversion ratio and the first boost stage also benefited the input current ripple reduction; 2) the leakage inductor energy of the coupled inductor can be recycled, which reduces the voltage stress on the active switch, and also the conversion efficiency is significantly improved.

II. OPERATING PRINCIPLE OF THE PROPOSED CONVERTER

The simplified circuit model of the proposed converter is shown in Fig 3. The dual-winding coupled inductor consisted of a magnetizing inductor L_m, primary leakage inductor L_{k1}, secondary leakage inductor L_{k2}, and an ideal transformer, which constituted the primary and secondary windings, N_1 and N_2, respectively. In order to simplify the circuit analysis of the proposed converter, some assumptions are stated as follows.

1) All components are ideally considered except the leakage inductor of the coupled inductor. The on State resistance $R_{DS(ON)}$ and all parasitic capacitors of the main switch S_1 are neglected; in addition, the forward voltage drop of the diodes D_1-D_4 is ignored.
2) All capacitors are sufficiently large, and the voltages across capacitors are considered as constant during one switching period.
3) The ESRs of all capacitors C_1, C_{o1}, and C_{o2} are neglected.
4) The turn ratio n of dual winding coupled inductor T_1 is equal to N_2/N_1.

III. SIMULATION RESULTS

The circuit of DC-AC converter system is shown in Fig 4(a). The output of solar cell is applied to the high step up DC-DC converter. The output of the converter is applied to the inverter. The AC output of the inverter is filtered using LC filter. The DC input voltage from the DC voltage of the solar cell is shown in Fig 4 (b). The input voltage is 15V. Measurement of power from the solar cell is shown in Fig 4 (c). The power is obtained by multiplying voltage (V) and current (I). The gate pulses and voltage across the switch are shown in Fig 4(d). The output voltage of the inverter with filter is shown in Fig 4(e). The current through the load is shown in Fig 4(f). It can be seen that the current is in phase with the voltage.

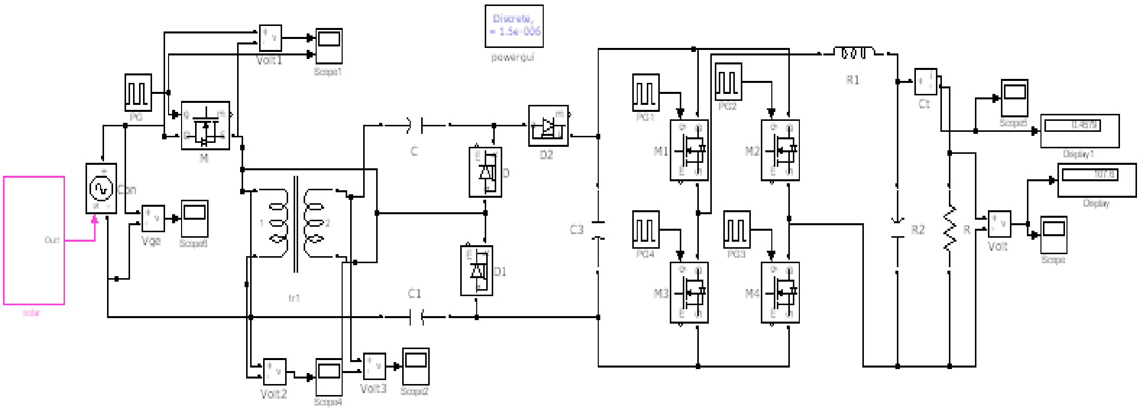

Fig .4(a) Circuit diagram of DC to AC Converter

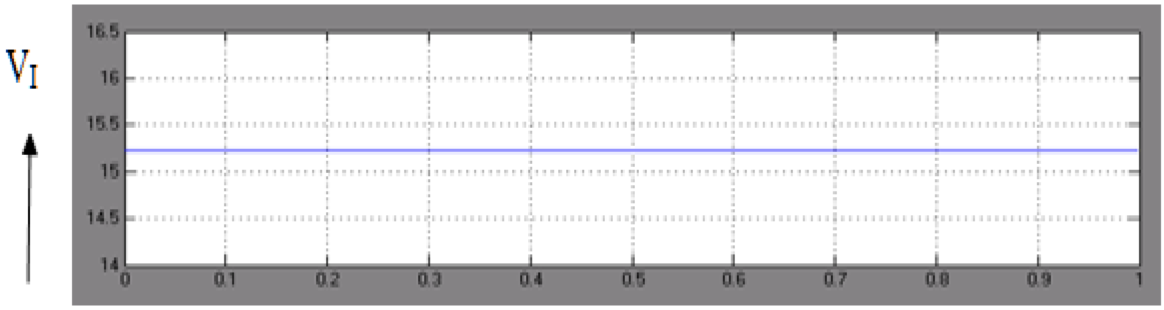

Fig.4(b) Input voltage

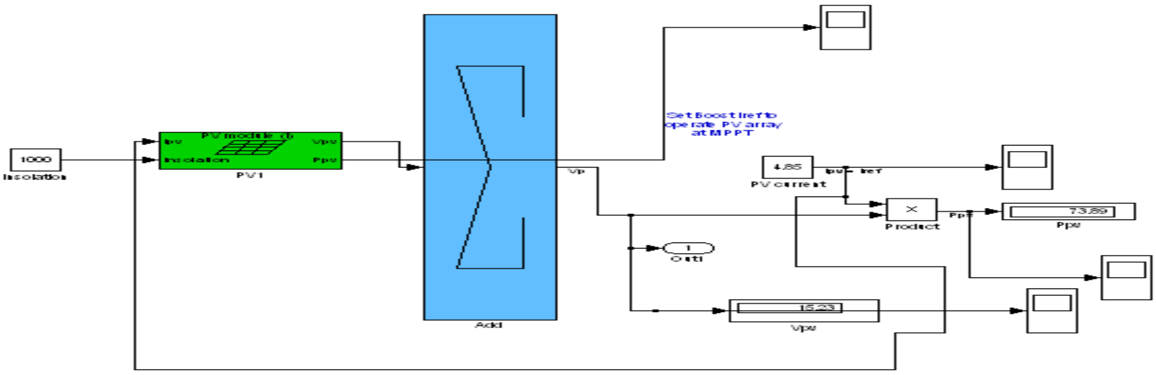

Fig.4(c) Measurement of Power

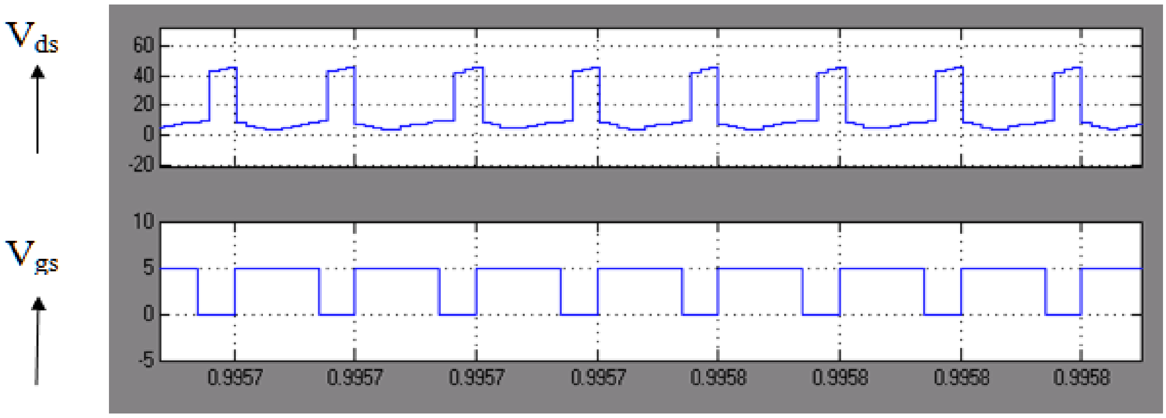

Fig.4 (d) Drain to source voltage and switching pulse ⟶ time

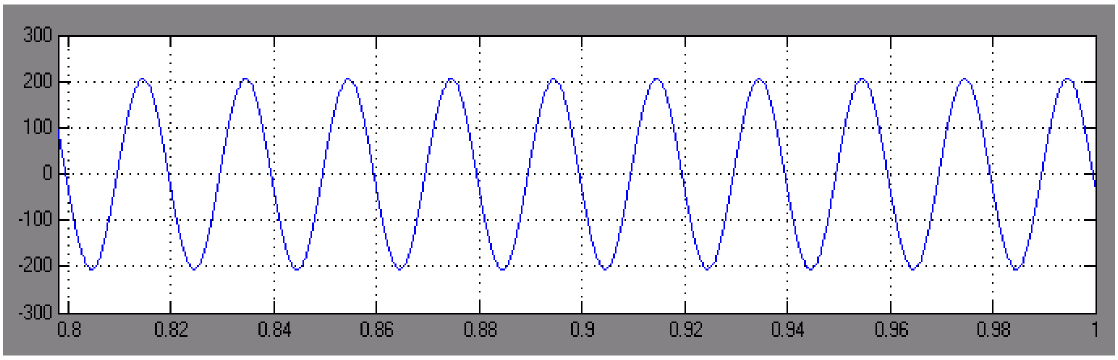

Fig.4 (e)Output voltage

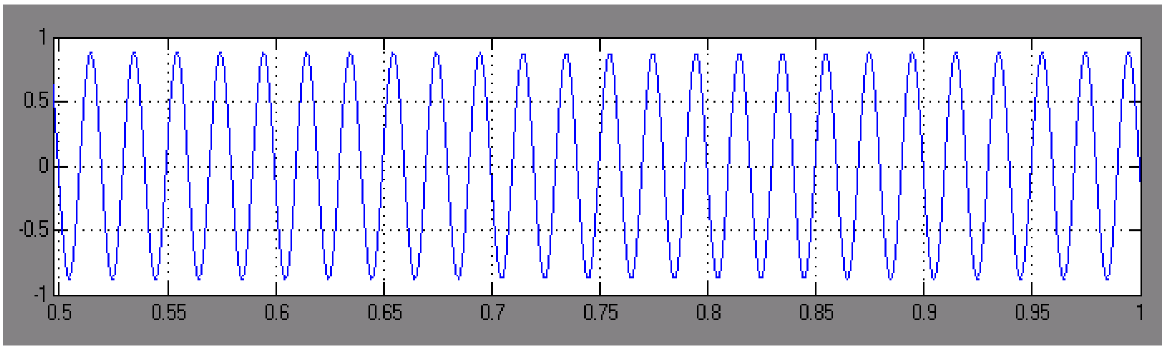

Fig.4 (f) Output current

IV. CONCLUSION

High step up DC-AC converter with microsource at the input is successfully modelled and simulated using MATLAB simulink. The results indicate that high step up DC-AC converter is capable of stepping up the voltage from 15V DC to 230V AC. This high step up DC-AC converter system is a viable alternative to the existing converters. The advantages of this converter are reduced hardware and nearly sinusoidal output voltage. The simulation results are in line with the predictions.

This converters can be used only for low current rated loads. The scope of this work is the modelling and simulation of high step up DC to AC converter. The hardware implementation will be done in future.

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