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High Gain Efficient DC-DC Converter for Low-Voltage Power Generation Application

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ABSTRACT

This paper presents a high-gain dc-dc converter topology that employs AN electrical converter circuit, boost device and voltage electronic device circuit. Boost converter used uses high frequency electrical device with an electrical device within the secondary rather than electrical device alone. This helps in utilizing the magnetic circuit optimally and eliminates the matter of electrical device saturation at higher currents. Usage of soft-switching more minimizes the switching losses & magnetism interference (EMI) problems. The planned system operates in DCM mode facilitating high gain & Zero-Current switch (ZCS) turn-ON for the {inverter|electrical device} and boost converter switches. Zero-Voltage switch (ZVS) technique throughout stimulus is also used for the electrical converter switches. additionally, the proposed configuration provides answer for a large operational voltage vary for DC supply. In total the given configuration provides high gain output voltage mistreatment boost converter & voltage electronic device circuit operational in AN efficient manner by using soft switch techniques. Details of working rule, modes of operation and simulation results are conferred within the manuscript.

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I. INTRODUCTION

The demand for electricity is increasing day by day, due to the advancements and innovations in electrical energy dependent applications from a simple mobile phone to heavy industrial machines. On the other hand, pollution hazards from the conventional way of power generation and threat of fossil fuel exhaustion limiting the conventional power generation to meet the load demand satisfactorily. There is a requirement for alternate sources of electrical energy (like Solar energy using Photo-Voltaic Cell technology, Wind energy using Wind-turbines, Fuel Cell technology, Piezo-electric materials, etc...) to make their way to meet the load reliably overcoming the challenges being faced by them. Apart from Wind-turbines, the other mentioned techniques have the challenge of power generation at low-voltage level for Photovoltaic (PV) cells, fuel cell and Piezo-electric material. These require a high gain converter with high efficiency and wider range of the operating input voltage. Many proposals for High-Gain Converters are there and among them, some good proposals based on resonant boost converter are given in literature [8-15]. Recently one interesting proposal on integrated resonant boost converter was given by La Thomas et.al.[14-15]. The proposed system can be operated with either frequency control or duty ratio control to maintain the output voltage at desired constant value irrespective of variations in input DC voltage. In the proposal [14] authors have used series resonant configuration combined with AC boost configuration with Discontinuous Current Mode (DCM). This configuration draws higher inductor currents for the requirement of higher conversion ratio that may lead to saturation of inductor. And also the design procedure followed limits the range of duty cycle to operate the converter in DCM. This paper proposes a topology that overcomes the limitation of inductor saturation. This uses the same number of components overcoming the problem of saturation. A proper design of transformer can eliminate the inductor also in the circuit. This makes the proposed configuration as a better and reliable solution for high-voltage low power generation applications with lesser cost, size and weight. Basic operation principle, modes of operation & analysis of the converter and simulation results are presented in the manuscript.

II. EXISTING SYSTEM

Pollution hazards from the conventional way of power generation and threat of fossil fuel exhaustion limiting the conventional power generation to meet the load demand satisfactorily. There is a requirement for alternate sources of electrical energy (like Solar energy using Photo-Voltaic Cell technology, Wind energy using Wind-turbines, Fuel Cell technology, Piezo-electric materials, etc...) to make their way to meet the load reliably overcoming the challenges being faced by them. Apart from Wind-turbines, the other mentioned techniques have the challenge of power generation at low-voltage level for Photovoltaic (PV) cells, fuel cell and Piezo-electric material. These require a high gain converter with high efficiency and wider range of the operating input voltage. Many proposals for High-Gain Converters are there and among them, some good proposals based on resonant boost converter are given in literature [8-15].

III. PROPOSED SYSTEM

The proposed system can be operated with either frequency control or duty ratio control to maintain the output voltage at desired constant value irrespective of variations in input DC voltage. In the proposal [14] authors have used series resonant configuration combined with AC boost configuration with Discontinuous Current Mode (DCM). This configuration draws higher inductor currents for the requirement of higher conversion ratio that may lead to saturation of inductor. And also the design procedure followed limits the range of duty cycle to operate the converter in DCM. This paper proposes a topology that overcomes the limitation of inductor saturation. This uses the same number of components overcoming the problem of saturation. A proper design of transformer can eliminate the inductor also in the circuit. This makes the proposed configuration as a better and reliable solution for high-voltage low power generation applications with lesser cost, size and weight. Basic operation principle, modes of operation & analysis of the converter and simulation results are presented in the manuscript.

Basic operation principle of the proposed configuration:

The schematic layout of the proposed high gain resonant boost converter. It is divided into three parts: (i) Inverter circuit (ii) Boost circuit (iii) Voltage-doubler circuit. First part consistsof full-bridge inverter circuit which consists of 4 switches (S1– S4) with drain-source parasitic capacitances (Cp1– Cp4) for each switch respectively as shown in the Fig.1. This inverter operates at near resonant frequency (fr) and converts input DC supply to high frequency AC (square wave) supply output. Second part is a boost converter which consists of a high frequency boost transformer along with an inductor (Lr), and a bi-directional boost switch. Bi-directional boost switch is realized by anti-series connection of two MOSFETS Sb1& Sb2as shown in the Fig.1. Boost switches (Sb1& Sb2) operates at twice the frequency of the inverter switches (i.e., 2fr). And, the third part consists of voltage doubler circuit, used for rectifying and also to increase the output voltage (Vo). It requires two fast switching diodes (Dvd1and Dvd2) with resonant voltage doubler capacitors (Cvd1and Cvd2).

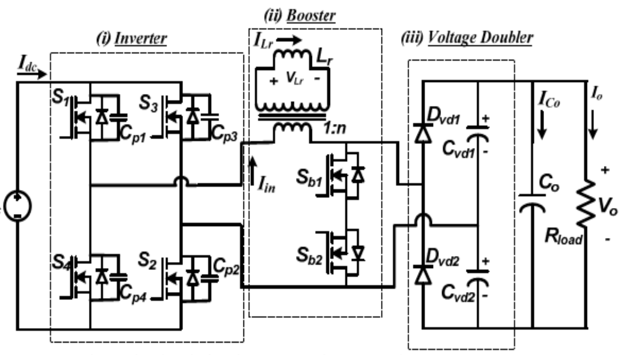

Fig. 1 Schematic circuit for the proposed resonant boost converter

Fig: Circuit Diagram

Modes of Operation

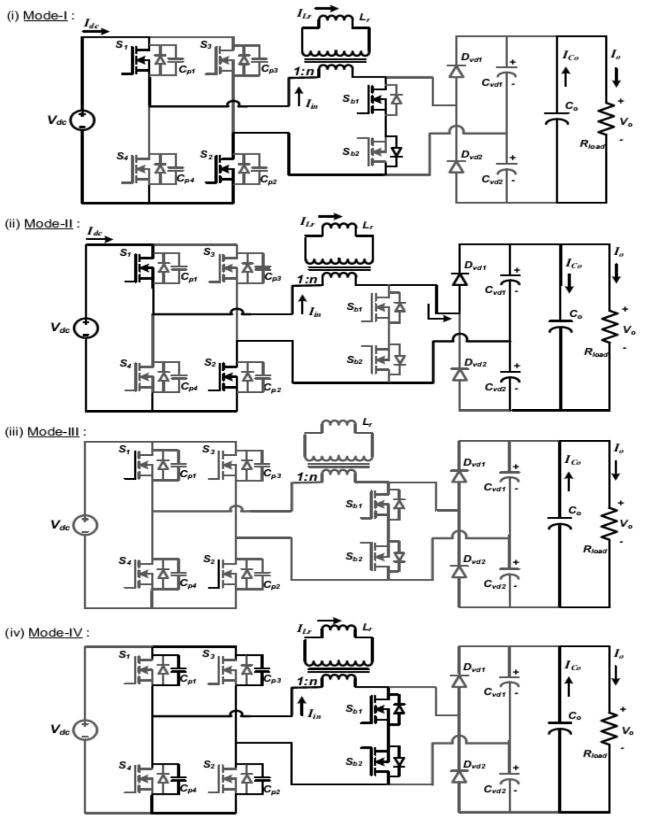

Fig. 2 Different modes of operation during positive cycle of the inverter output voltage

IV. SIMULATION RESULTS

The proposed converter was simulated using PSIM simulation software. The following parameter values are used for the simulation of proposed converter. The simulation parameter values, input voltage (*Vdc*), operating frequency (*f*), inverter switches' duty cycle (*dinv*), bi-directional boost switch duty cycle (*db*), Load (*RL*), Inductance (*Lr*), turns' ratio (*n*) and capacitance value of voltage doubler circuit (*Cvd1* &*Cvd2*) are tabulated in Table 1. And a dead band of 200ns is considered for the gating pulses of the inverter switches. A small dead-band period of 200ns can be observed in the inverter switches' gating pulses from Fig. 5 (a). Boost transformer primary and secondary current waveforms are shown in Fig. 5 (c). It can be observed that the secondary current is 1/n times the primary current (i.e., input current). This helps in limiting the peak current and minimizing the chances of saturation of inductor in the boost transformer secondary circuit.

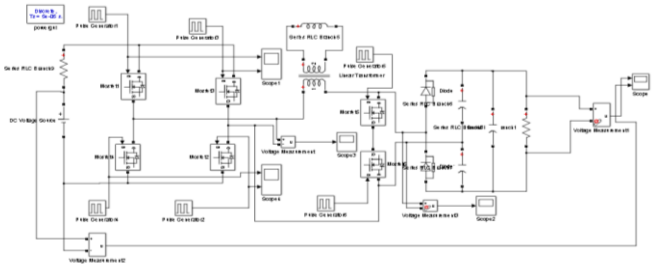

Figure 3

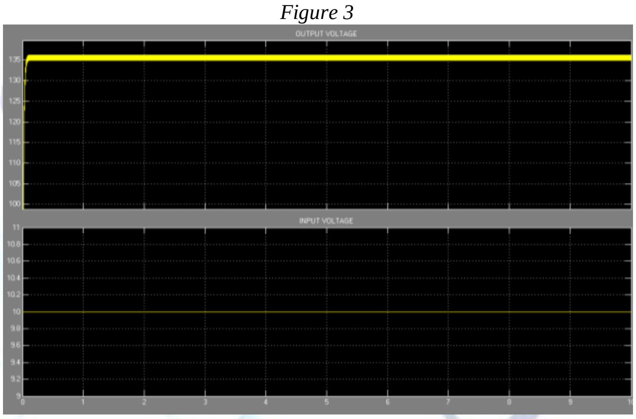

Figure 4

V. CONCLUSION

In this paper a high gain boost resonant converter is proposed. The complete details of the working principle and modes of operation are described in this manuscript. By employing a transformer with an inductor in secondary instead of inductor alone, the problem of inductor saturation is eliminated. Further, the converter uses PWM control of the bi-directional switch to regulate the output voltage. Thus, the converter has the advantage of both resonant and PWM converter. Another advantage of the proposed configuration is it exhibit ZCS operation (due to discontinuous mode) and ZVS turn-ON (due to dead band) results in low switching losses which make the converter more efficient. In brief, benefits of high gain, low losses and soft-switching feature make the topology a better solution for low-voltage power generation. And low switching losses gives room for operating the converter at higher frequency which can lead to compact designs and mainly becomes handy in the design of portable applications.

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