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Study on High Step-up DC-DC Converter with High Gain Cell for PV Applications

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Abstract

High gain dc-dc converters are fast growing switching power converters for Photo Voltaic (PV) applications. Researchers are developing different topologies to achieve higher voltage gain, low switch stress, low ripple, and cost efficient converters. This paper studies various High Gain (HG) cells and its performance is analyzed by combining the cell to the quadratic boost converter. We made a comparative study on all the types of HG cell concerning voltage gain, voltage stress and switch utilization factor, and efficiency. Simulation is carried out in the nl5 simulator. Finally, an efficient HG cell is determined in positive output HG cell.

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Keywords: DC-DC converter; Topology; High Gain(HG) cell; voltage gain; voltage stress.

1. Introduction

The total installed grid connected solar power capacity in India is about 8 GW as of 2016. Indian government has planned to invest $100 billion to expand the solar plants to 100 GW by 2022. To achieve high efficiency in this Renewable energy system (RES), the energy conversion system should improved by implementing novel and efficient topologies. The high voltage dc-dc converter is presented in the year 1997 with voltage multiplier, and it is

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advantageous in weight and size compared to conventional switched mode regulator [1]. M. S. Makowski addressed the question relating to the number of circuit elements required to achieve the particular voltage gain [18].

Nomenclature

HG	High Gain
PQBHGC	Positive output Quadratic Boost Converter with High Gain Cell
D	Duty cycle
Vo	Output voltage
Vg	Input voltage
V_L	Inductor voltage
V_C	Capacitor voltage
V_{CM}	Multiplier capacitor voltage

For the last decade, many types of research are going on the high gain dc-dc converters. It can be realized by adding High Gain (HG) cell before the output of the converter. Three state switching cells combined with voltage multiplier cell to increase the output voltage. However, the converter is bulky due the presence of auto transformer [3][17]. Zero voltage switching and zero current switching are proposed for the high step-up dc-dc converter with voltage multiplier cell [16]. Leakage inductance in the active clamp coupled inductor based dc-dc converter affects the voltage gain of the converter. This drawback is overcome by combining coupled inductor and voltage multiplier cell which reduces the high pulse current in the voltage doubler cell [8].Modified interleaved boost converter is integrated with voltage multiplier module with dual coupled inductor to balance the primary currents [5].

The most predominately used HG cell are given in Table 1. Table 1 provides different connection of Diode-Capacitor (D-C) cell and Diode-Capacitor-Inductor (D-C-L) cell. Initially used voltage multiplier circuits are Villard, Heinrich Greinacher, Dickson and Cockcroft-Walton circuits to achieve high output voltage. The HGC-2 cell is combined with voltage lift circuit to obtain low voltage stress on the switches [14]. The HGC-3 cell is Dickson multiplier cell and, it is used to derive significant voltage dc-dc converter in [15][23]. In [12] Dickson cell is used along with switched coupled inductor to increase the voltage gain. Diode reverse recovery losses are alleviated in the converter proposed with interleaved three winding coupled inductor with voltage multiplier cell [7]. The HGC-3 cell is integrated with conventional boost converter, and its performance is thoroughly studied in [10]. Ultra step-up dc-dc converter is derived with the HGC-3 cell in [4]. In [10] multiphase dc-dc converter is combined with HGC-7 cell to reduce input current ripple and for proper current sharing in the components of the converters. It is also in the interleaved boost converter with alternating phase shift control scheme [13]. Chung-Ming Young et al, proposed transformerless high step-up dc-dc converter with Cockcroft-Walton (HGC-5) cell for small input dc system [2]. HGC-9 is proposed as the bidirectional dc-dc converter in [6]. HGC-1 and HGC-15 are proposed in [11] for increasing PV cell voltage. HGC-2, 4,11,12,13 are proposed as inverting and non-inverting cell to derive a family of single switch high step-up dc-dc converter [19]. HGC-8 and HGC-14 are presented as four terminals PWM switch to achieve reduced voltage stress in [20]. HGC-10 is a Marx generator and a dc-dc converter is presented on this principle to generate the higher voltage in [27]. HGC-6 is quasi z-source network, -and it is used to derive Step-up dc-dc converters by cascading quasi z-source cell [28].

This paper is organized as follows: Section 1 gives the introduction about the high gain dc-dc converter with voltage multiplier cell. Section 2 provides the general representation of dc-dc converter with HG cell. Section 3 provides the steady state analysis of PQBHGC. Section 4 gives the comparison of different HG cell. Section 5 concludes the work.