Design of A Novel Power Boost Converter With Dual Coupled Inductors

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***Abstract*— The conventional DC-DC boost converters are widely used in several applications. They have the shortcomings of low voltage gain ratio and discontinuous output current. Reverse recovery problem may arise in the output diode which can harm the power switch. DC-DC converters having high gain are fast developing switching power converters in the field of like that Photo Voltaic (PV) applications, fuel cell and wind energy and others low constant energy producing systems, dc back-up energy systems, high-intensity discharge lamp, electric vehicles. Research is going on to develop different topologies for achieving higher voltage gain, low ripple, reduced switch stress, and cost effective converters. In this paper various High Gain cells are being studied. This paper also proposed a boost converter with dual coupled inductors with uninterrupted input current. Moreover, this makes it a appropriate choice for fuel cells. Simulations are done in MATLAB Simulink to verify the theoretical equations from the planned converter configuration.**

Keywords*— High gain cell, Boost converters, Coupled inductor, Continuous current

I. INTRODUCTION

Due to the substantial increase in environmental pollution, reduction of fossil fuel assets and their high prices, developing countries planned to use the alternate sources such as: Photovoltaic (PV), wind turbines and fuel cells . Mostly, they provide dc voltages at the output side which are normally low [1-3]. For example, to attain a higher voltage level for PV panels, series combinations of sources are used which witnesses various advantages and disadvantages also. If multiple solar modules connected in series and they do not receive uniform irradiation, the extracted power decreases in comparison with the available power. In this circuit maximum power point tracking is another challenge [4], which can be solved by utilizing the separated DC-DC boost converters. Normally, the key reason of applying a boost converter is to control these sources self-sufficiently and also transmitting energy from these sources along with delivering to the power grid at higher voltage levels [5]. The voltage level of the converter can be increased by increasing the duty cycle. Though out, problem saturation, and low efficiency, it is a very tough task to increase the conversion ratio. Need for continuous power in the input and output of the boost converter is another process. However, fundamental DC-DC boost converter gives discontinuous output power. This limitation creates significant ripples at the output and place the output diode in risk of problem [6-9]. The continuous currents become more important when absorbed power of PV panels depends on the converter's input power. Hence, if the input current is discontinuous, based on PV current and power characteristic the amount of output energy decrease. Again continuous output current is very important to adjust output power in some sources. To build a continuous current, a power converter can be designed with inductors in the input and the output side of the converter [10]. For few decades, various types of research work are going on the field of DC converters. It can be done by combining with High Gain cell at the converter output side. The mostly used High Gain cells are given in Table no. 1. The Table no. 1 shows different types of connection of Diode - Capacitor cell and Diode-Capacitor-Inductor cell. Different types of voltage circuits such as Heinrich Greinacher, Cockcroft-Walton, Villard and Dickson circuits are used to achieve high output voltage. High gain cell (HGC)-1 is proposed for increasing PV cell voltage in [11]. The HGC-2 cell is added with voltage circuit to get low voltage stress upon the switching devices [12]. The HGC-3 cell is also known as Dickson multiplier cell and, it is used to achieve notable voltage at the DC-DC converter in [13]. The HGC-3 cell is integrated with converter which is boost conventional [10]. HGC-3 cell is also executed in Ultra step-up DC-DC converter [14]. Chung-Ming Young et al, developed a transformer less step-up DC-DC converter for small input dc system with Cockcroft-Walton (HGC-6) cell [15]. HGC-5 is used to execute Step-up dc-dc boost converter by combining with quasi z-source cell [16]. Over all, a suitable DC-DC boost converter should have the beneficial features like: low power losses, high voltage gain ratio, less stress across the power switch and diodes, less number of elements, lower volume and weight, and also having continuous input and output current [17-19]. This paper proposes a novel power boost converter with dual coupled inductors. This paper is divided into four parts. The proposed converter configuration is discussed in section II. Steady state analysis and assumptions of the converter are provided in section III. Section IV is expressed to results given by simulation.

II. PROPOSED CONVERTER CONFIGURATION

The proposed converter is shown as in fig 1. The converter consists of two power switches S1 and S2, two coupled mutual inductors MI and MI 1, three diodes and three capacitors C1, C2 and C3 and three inductors L1, L2 and L3. The mutual inductors are of same value. The converter's working can be explained with two modes, mode 1: S1on, S2off and mode 2: S1off, S2on.

The figure shows the converter switches operating in the ON condition, the mutual inductors MI and MI 1, inductors L1, L2, L3 gets charged by the input power source, as the inductors absorbs energy. The MOSFET is given repeating gate pulse with the help of pulse width modulation Generator. The input signal of gate pulse is made stable with the help of PWM Generator having 1 KHz frequency. Diode allows only the forward current to flow through the connected capacitor and resistors. During ON condition, inductors stores energy, and during OFF condition the stored energy of the inductors are released through the output load and charges capacitors.

III. STEADY STATE ANALYSIS AND ASSUMPSION OF THE CONVERTER

To simplify the circuit performance analysis of the converter in continuous conduction mode, the following assumptions are made.

1. Two MOSFET switches are ideal.
2. The coupling-coefficient k of each coupled inductor is defined as

$$K = \frac{M}{\sqrt{(L1+L2)}}$$

The turn ratio N of each coupled inductor is equal to NS /NP .

3. The value of two coupled inductor which parameters are considered to be the equal.

A. *Voltage gain:*

If the transient period of circuit is neglected each magnetizing inductance has two states in one switching period. In first state, the magnetizing inductance is charged throughout the input source. In the other state, the magnetizing inductance is discharged by the output capacitor voltage.

$$V_o = V_{C2} + V_{C3}$$

To simplify the voltage analyses of the components, the leakage inductance of coupled inductor and the voltage ripples on the capacitors are overlooked. Thus ideal voltage gain is written as

$$Gain = \frac{V_o 2(N+1)}{V_{in}(1-D)}$$

D is the duty ratio;

IV. SIMULATION AND RESULT

The simulation of circuit has been done using MATLAB/ Simulink 2021 version software. Fig 2 represents the circuit used for simulation. Fig 3shows the switching pulses, Fig 4 Shows output voltage waveform and Fig 5 shows output current waveform respectively.

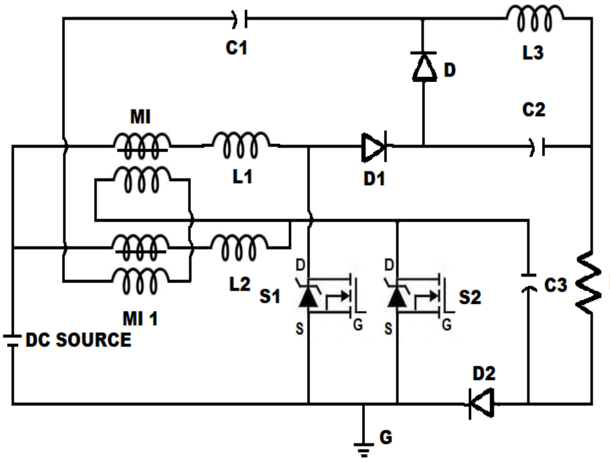

Fig.1: Proposed converter configuration

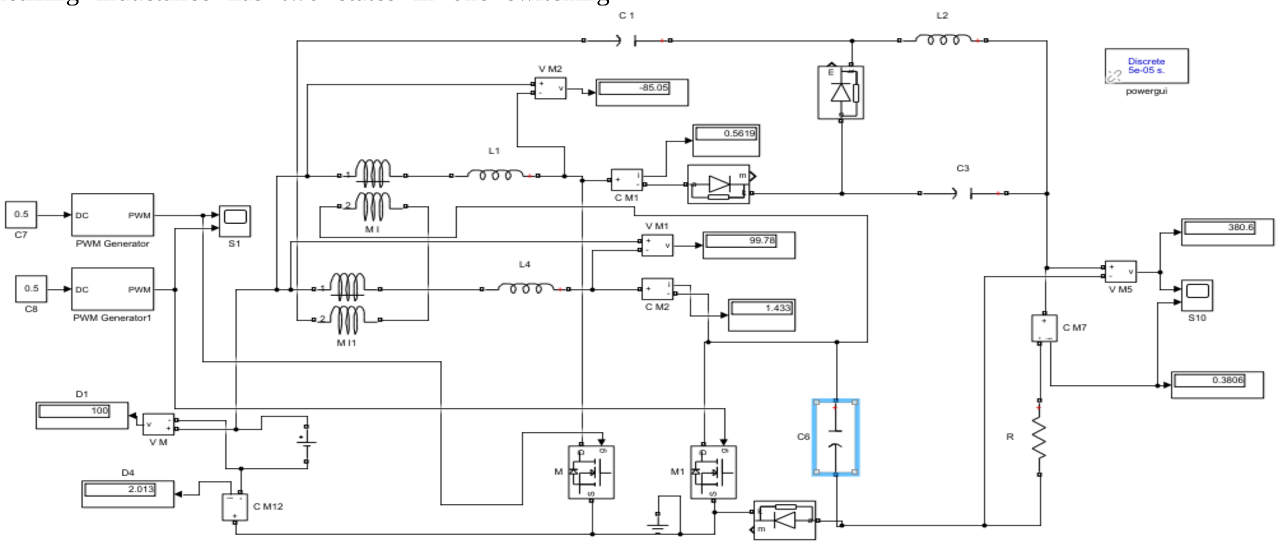

Fig.2: Simulation circuit of converter

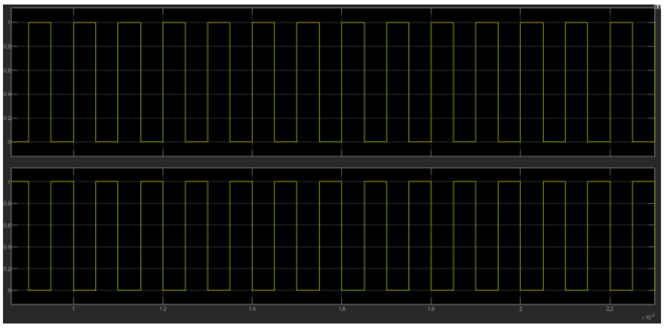

Fig: 3: Switching Pulses

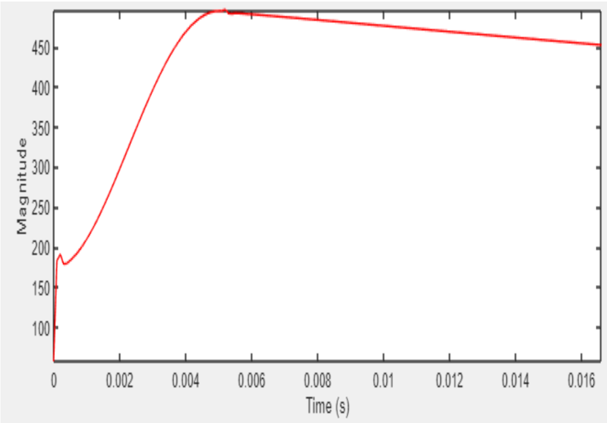

Fig: 4 : Output Voltage Waveform

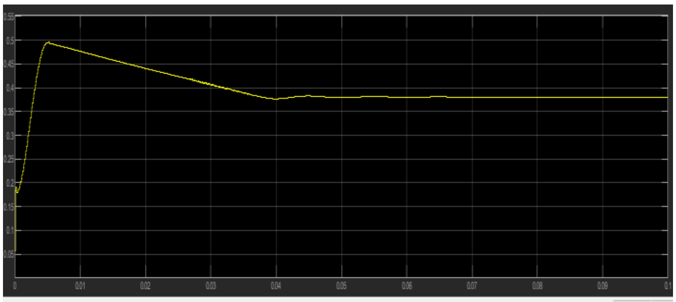

Fig: 5: Output Current Waveform

Table 1: Result and parameters

Parameter	Value
Input Voltage(V_{in})	100V
Output Voltage(V_O)	380.6V
Rated Load Resistance(R)	1 K ohm
Inductors (L1, L2, L3)	5 mH
Capacitor(C1, C2, C3)	10 microfarad
MOSFET (M, M1)	N-Channel

The parameters of proposed high gain dc-dc converter are given in the table above. The high gain of input power was seen in the output side. The duty cycle is 0.5 (50%). A stable gate pulse was generated using PWM. Input power is 201.3W and output power is 144.85W. Rest of the power is being lost in other elements. But the output voltage is very high than the input supply voltage. By seeing the results we can very surely tell the results met the expectations.

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