

SIMULATION OF HIGH BOOST CONVERTER FOR CONTINUOUS AND DISCONTINUOUS MODE OF OPERATION WITH COUPLED INDUCTOR

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Abstract- In this work, High boost converter is analyzed and designed with given parameters, is design to boost low voltages to voltages into high range of 30 to 50 times input voltage. It is especially useful in boosting low solar panel voltage to high voltage, so that 230V ac can be generated. At the time the efficiency is also high and it is cost effective. It is a transformer less topology. This converter will work with input voltage of 25V DC, and generate constant output voltage of 440 V DC with the help of PI controller. To achieve high voltage output gain the converter output terminal and boost output terminal are connected in serially with the isolated inductor with less voltage stress on controlled power switch and power diodes. tested with simulation software. This paper explains modeling analysis and simulation of high boost converter for continuous and discontinuous mode of operation with coupled inductor for low power application. Input to the high boost converter is the unregulated supply which is obtained by rectifying AC supply. In the proposed model, DC battery fictitiously represents the unregulated supply. All the results are observed and compared when controlling scheme in the high boost circuit designed with coupled inductor.

Keyword – Coupled Inductor, Input Inductor, Filter, Capacitor, and Simulink.

1. INTRODUCTION:

The high gain DC-DC converter with coupling inductor is design to boost low voltages to voltages into high range of 30 to 50 times input voltage. It is especially useful in boosting low solar panel voltage to high voltage, so that 230V ac can be generated. At the time the efficiency is also high and it is cost effective. It is a transformer less topology. This converter will work with input voltage of 25V dc, and generate constant output voltage of 440 V dc with the help of PI controller. To achieve high voltage output, gain the converter output terminal and boost output terminal are connected in serially with the isolated inductor with less voltage stress on controlled power switch and power diodes. PSIM software has been used for simulation.

To verify the performance of the proposed converter, a 345-W prototype sample is implemented with an input voltage range of 20–40 V and an output voltage of up to 440 V. The upmost efficiency of 93.3% is reached with

high-line input; on the other hand, the full-load efficiency remains at 89.3% during low-line input.

High boost dc-dc converter operating at high voltage regulation is mainly required in many industrial applications. High gain dc-dc boost converter play a important role in renewable energy sources such as solar energy system, fuel energy system, DC back up energy system of UPS, High intensity discharge lamp and automobile applications. For battery-powered systems, electric vehicles, fuel cell systems, and photovoltaic systems, where low-voltage sources need to be converted into high voltages, the demand for non-isolated high step-up dc-dc conversion techniques are gradually increasing.

This paper presents a cascaded high step-up dc-dc converter to increase the output voltage of the micro source 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. The circuit diagram of the proposed converter is shown in Fig.1

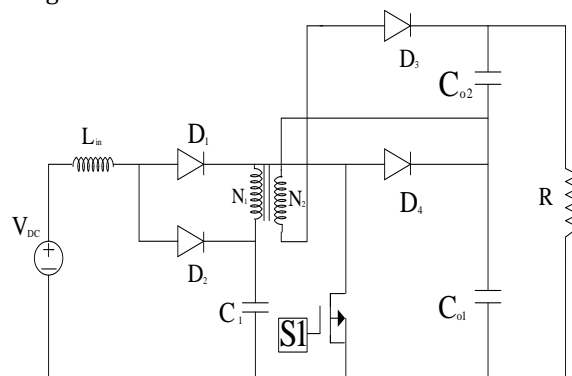


Fig.1: High boost converter topology

2. PRINCIPLE OF OPERATION:

The simplified circuit model of the proposed converter is shown in Fig.1. 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.

- 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.
- All capacitors are sufficiently large, and the voltages across capacitors are considered as constant during one switching period.
- The ESRs of all capacitors C_1 , C_{01} , and C_{02} are neglected.
- The turn ratio η of dual-winding coupled inductor T_1 is equal to $\frac{N_1}{N_2}$.

2.1 CONTINUOUS CONDUCTION MODE:

Fig.2 shows several typical waveforms during five operating modes at one switching period T_s while both the input inductor L_{in} and the magnetizing inductor L_m are operated in CCM. The operating modes are described as follows.

2.1.1 MODE 1 [t_0, t_1]:

In this transition interval, switch S_1 is turned ON. Diodes D_1 and D_3 are conducted but diodes D_2 and D_4 are turned OFF. The path of the current flow through the conduction element. The energy of the dc source V_{in} is transferred to the input inductor L_{in} through the diode D_1 , and the voltage across the input inductor L_{in} is V_{in} ; the input current i_{in} is equal to i_{D1} and is increased. The capacitor C_1 delivers its energy to the magnetizing inductor L_m and the primary leakage inductor L_{k1} . The voltage across the magnetizing inductor L_m and the primary leakage inductor L_{k1} is V_{C1} , but the magnetizing inductor L_m keeps on transferring its energy through the secondary leakage inductor L_{k2} to the charge capacitor C_{01} so that both currents i_{Lk2} and i_{Lm} decrease, until the increasing i_{Lk1} reaches and equals to decreasing i_{Lm} in the meantime, the current i_{Lk2} is down to zero at $t = t_1$ this mode is ended. The energies stored in capacitors C_{01} and C_{02} are constantly discharged to the load R .

2.1.2 MODE 2 [t_1, t_2]:

During this interval, the switch S_1 is remained ON. Only the diode D_1 is conducted and rest of other diodes D_2 , D_3 , and D_4 are turned OFF. The path of the current flow through the conduction element. The energy of the dc source V_{in} is still stored into the input inductor L_{in} through the diode D_1 . The energy that has charged the capacitor C_1 is still delivered to the magnetizing inductor L_m and primary leakage inductor L_{k1} . The voltage across magnetizing inductor L_m and primary leakage inductor L_{k1} is V_{C1} . Thus, currents i_{in} , i_{D1} , i_{Lm} , and i_{Lk1} are increased. The energies stored in capacitors C_{01} and C_{02}

are still discharged to the load R . This mode is ended when switch S_1 is turned OFF at $t = t_2$.

2.1.3 MODE 3 [t_2, t_3]:

During this interval, switch S_1 and diode D_1 are turned OFF; the diodes D_2 , D_3 , and D_4 are conducted. The path of the current flow through the conduction element. The dc source V_{in} and input inductor L_{in} are connected serially to the charge capacitor C_1 with their energies. Meanwhile, the primary leakage inductor L_{k1} is in series with capacitor C_1 as a voltage source V_{C1} through magnetizing inductor L_m then delivered their energies to the charge capacitor C_{01} . The magnetizing inductor L_m also transferred the magnetizing energy through coupled Inductor T_1 to secondary leakage inductor L_{k2} and to charge capacitor C_{02} . Thus, currents i_{in} , i_{D2} , i_{D4} , i_{Lm} , and i_{Lk1} are decreased, but currents i_{C1} , i_{Lk2} , and i_{D3} are increased. The energies stored in capacitors C_{01} and C_{02} are discharged to the load R . This mode is ended when the current i_{C01} is dropped till zero at $t = t_3$.

2.1.4 MODE 4 [t_3, t_4]:

During this transition interval, switch S_1 and diode D_1 are remained OFF; and diodes D_2 , D_3 , and D_4 are still conducted. The path of the current flow through the conduction element. Almost statuses are remained as Mode 3 except the condition of primary leakage inductor L_{k1} is in series with capacitor C_1 as a voltage source V_{C1} through magnetizing inductor L_m then discharged or released their energies to load. Thus, currents i_{in} , i_{D2} , i_{D4} , i_{Lm} , and i_{Lk1} are persistently decreased, but currents i_{C02} , i_{Lk2} , and i_{D3} are still increased. The energy stored in capacitors C_{01} and C_{02} is discharged to the load R . This mode is ended when current i_{Lk1} is decreased until zero at $t = t_3$.

2.1.5 MODE 5 [t_4, t_5]:

During this interval, switch S_1 and diode D_1 are remaining OFF; diode D_4 is turned OFF and diodes D_2 and D_3 are keep conducted. The path of the current flow through the conduction element. The path of the current flow through the conduction element. The dc source V_{in} and input inductor L_{in} are connected serially and still charged to capacitor C_1 with their energies. The magnetizing inductor L_m continuously transferred its own magnetizing energy through coupled inductor T_1 and diode D_3 to the secondary leakage inductor L_{k2} and to the charge capacitor C_{02} . Thus, currents i_{in} , i_{D2} , i_{D3} , i_{Lk2} , and i_m are decreased. The energies stored in capacitors C_{01} and C_{02} are discharged to the load. This mode is end when switch S_1 is turned ON at the beginning of the next switching period.

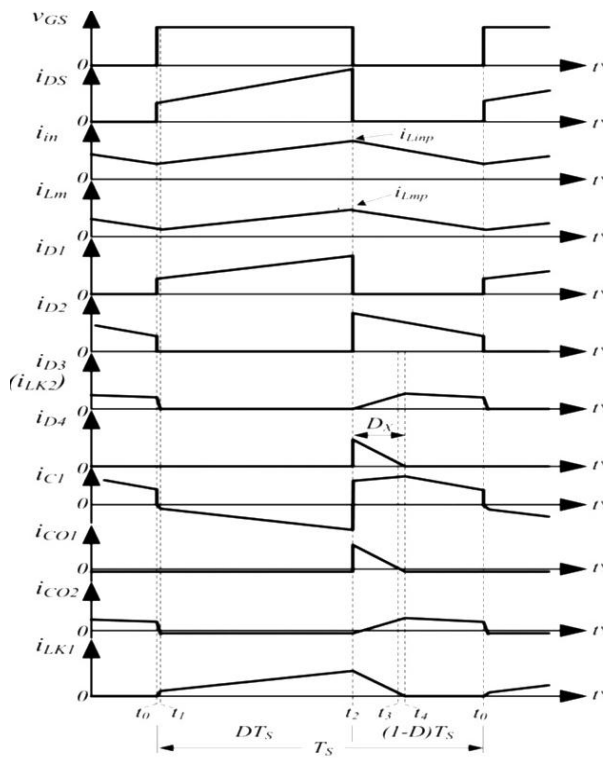


Fig.2. Some typical waveforms of the proposed converter both L_m and L_{in} are CCM operation

3. CONTROL SCHEME:

3.1 Open Loop:

a) Pulse generator- Firing of switch is controlled by pulse generator; switch is fired at fixed duty ratio. Duty ratio is calculated as-

$$\alpha = \frac{T_{on}}{T}$$

Where, T_{on} the on time of cycle and T is the total time.

b) Pwm generator- The duty cycle of V_{gs} (gate source voltage) is what allows a boost converter to function. As D increases, the gain also increases. In order to create a duty cycle, a PWM is required. There are several methods of creating a PWM. Here a repeating sequence and sine wave feed with a relational operator than generated a pulse. The operation is similar to the digital signal transmission using PWM signals.

3.2 Closed Loop:

Fig.3 shows the block diagram of closed loop control scheme. Firing of switch is controlled by the output voltage and inner current loop. The output voltage is sensed and is compared with a reference values. The error generated is passed through a PI controller now the output of PI controller is compared with the input current, the error then generated is fed as an input to the PWM generator and output is given to the switch.

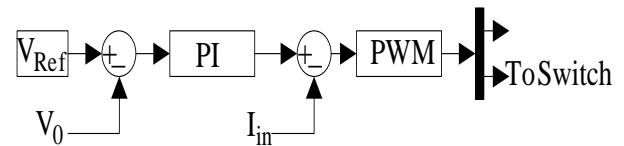


Fig.3 Block diagram for closed loop control

4. SIMULATION IMPLEMENTATION:

Fig.4 represents the simulation of the High-Boost converter for continuous and discontinuous mode. Before implementation of hardware it is usually advised to simulate the circuit because of the following reasons. Simulation saves a lot of human efforts we can make changes in the circuitry and observe the results thus obtained. It saves time since simulation is more flexible compared to hardware.

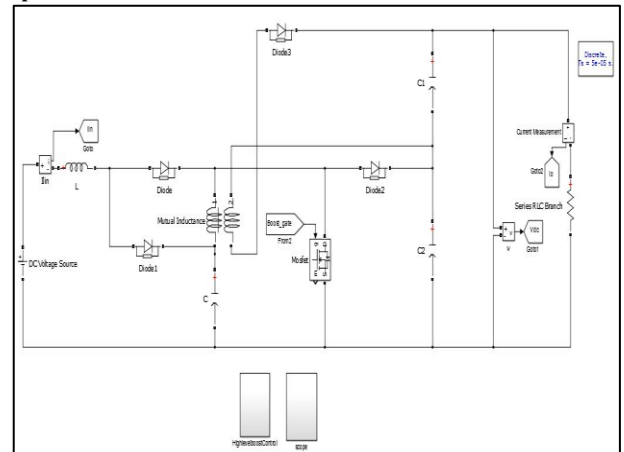


Fig.4 Simulation model of high boost converter in CCM

5. RESULT AND DISCUSSION:

Simulation of high step-up boost converter for continuous conduction mode of operation. The boost converter system is composed mainly of dc source (solar panel), coupled inductor, output filter, diodes, load resistance, MOSFET, snubber circuit etc. Below fig. shows the result of boost converter for continuous conduction mode of operation for open loop (pulse generator and sin PWM) and closed loop configuration. A 345-W prototype sample is presented to demonstrate the practicability of the proposed converter. The electrical specification is $V_{DC} = 25$ V, $V_o = 440$ V, $f_s = 40$ kHz, and $P_o = 345$ W (the full-load resistance $R = 570$ ohm). The requirement of major components such as $C_1 = 1000 \mu\text{F}$ and C_{o1} is the same as $C_{o2} = 550 \mu\text{F}$, the main switch S_1 is MOSFET, both the diodes $D1, D2, D3,$ and $D4$. The parameters selected for simulation studies are given in table below-

System Parameters	Values
Source voltage (V_{dc}) & output voltage(V_o)	25 V & 440 V
Inductor	2.67e-03
Filter impedance ($C_{01}C_{02}$)	500 μ F
Load impedance(R_L)	570 Ω
Switching frequency (f_s)	40 kHz
Mutual inductance	
Winding 1 self-impedance [R_1 (Ohm) L_1 (H)]:	[0.000000001 94e-06]
Winding 2 self-impedance [R_2 (Ohm) L_2 (H)]:	[0.000000001 94e-06]
Mutual impedance [R_m (Ohm) L_m (H)]:	[0.0000000001 93e-06]

Table: System parameters for simulation study
 The results obtained with pulse generator control scheme are as follows: fig. 5 shows the wave form of inductor current in continuous conduction mode of operation in open loop control of high step-up boost converter

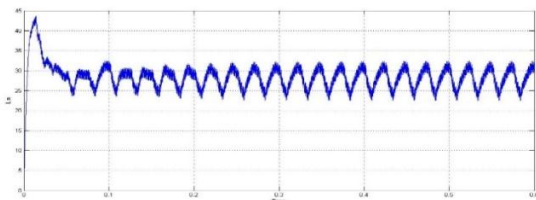


Fig.5 wave form of inductor current

Fig.6 shows the wave form of MOSFET current and voltage in continuous conduction mode of operation in open loop control of high step-up boost converter.

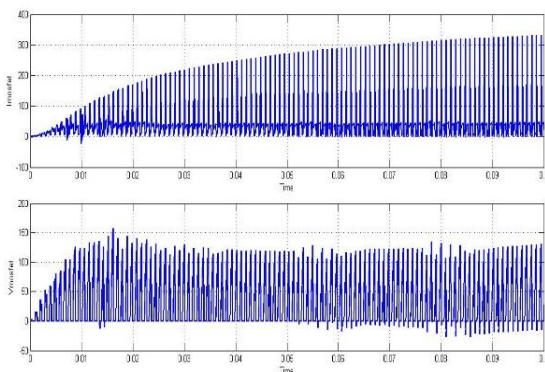


Fig.6 shows the MOSFET current and MOSFET voltage for the boost converter.

Fig.7 shows the wave form of output voltage and output current of ccm

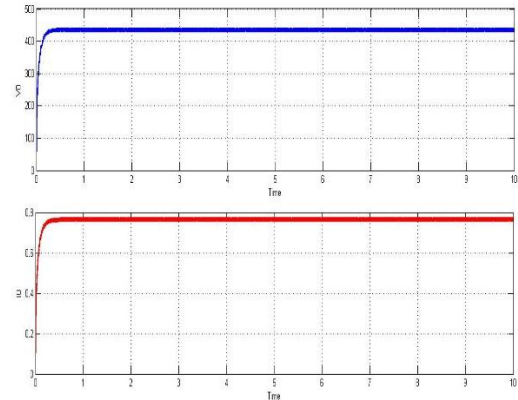


Fig.7 wave form of output voltage and output current of ccm

Fig.8 shows the wave form of output voltage and inductor current in continuous conduction mode in open loop control of high step-up boost converter.

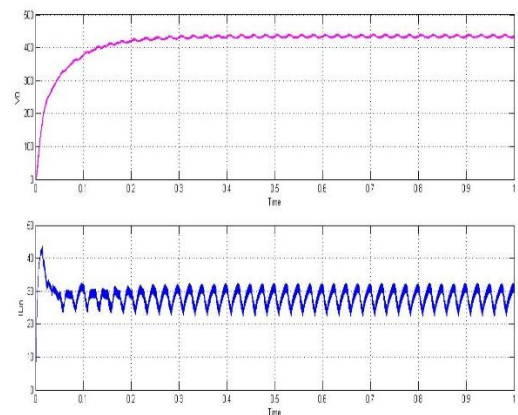


Fig.8 wave form of output voltage and inductor current of ccm

Fig.9 shows the wave form of output power in continuous conduction mode in open loop control of high step-up boost converter.

Fig.9 shows the wave form of output power in continuous conduction mode in open loop control of high step-up boost converter.

The results obtained with pulse width modulation (Pwm) control scheme are as follows: fig. 10 shows the wave form of inductor current in continuous conduction mode of operation in open loop control of high step-up boost converter.

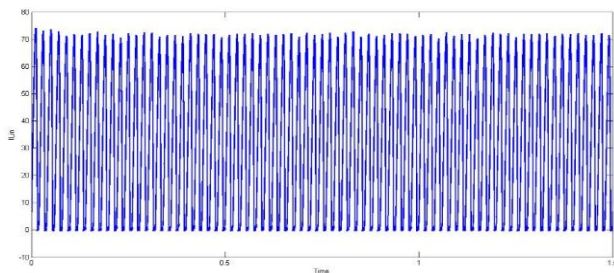


Fig.10 wave form of inductor current

Fig.11 shows the wave form of MOSFET current and voltage in continuous conduction mode of operation in open loop control of high step-up boost converter.

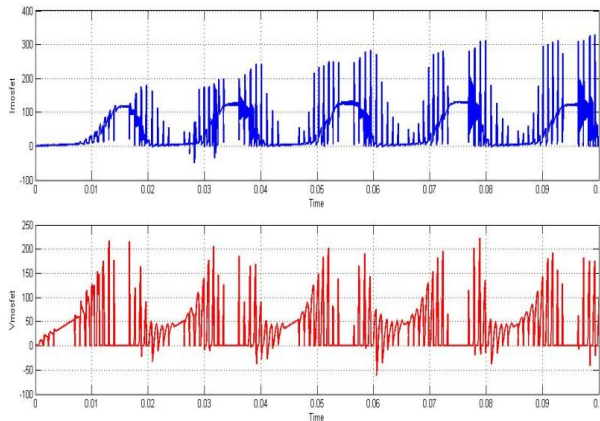


Fig.11 shows the MOSFET current and MOSFET voltage for the boost converter.

Fig.12 shows the wave form of output voltage and output current in continuous conduction mode in open loop control of high step-up boost converter.

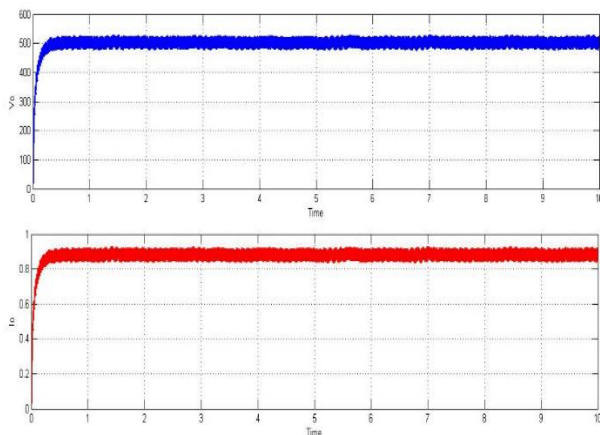


Fig.12 wave form of output voltage and output current of ccm

Fig.13 shows the wave form of output voltage and inductor current in continuous conduction mode in open loop control of high step-up boost converter.

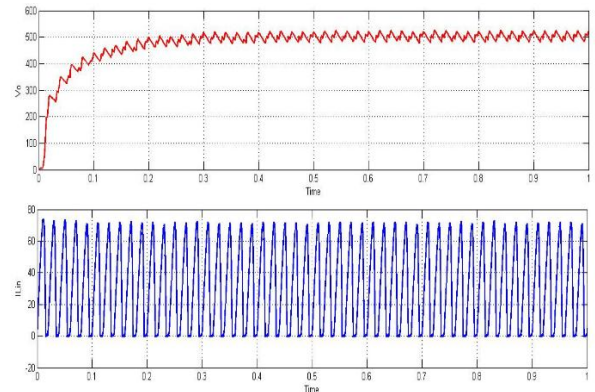


Fig.13 wave form of output voltage and inductor current of ccm

Fig.14 shows the wave form of output power in continuous conduction mode in open loop control of high step-up boost converter.

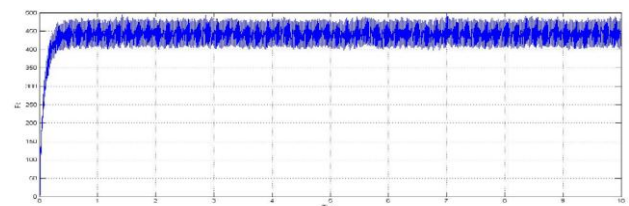


Fig.14 wave form of output power of ccm

Fig.15 shows the wave form of MOSFET current and voltage in continuous conduction mode of operation in closed loop control of high step-up boost converter.

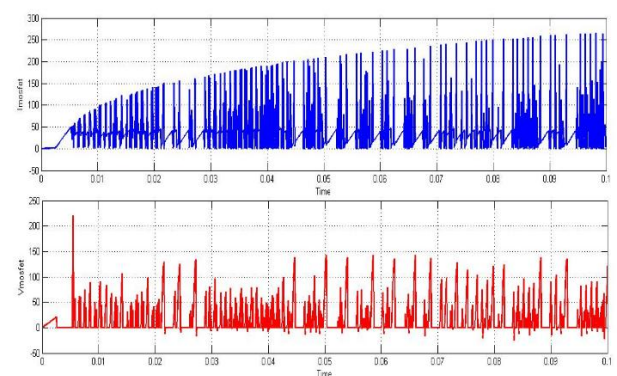


Fig.15 shows the MOSFET current and MOSFET voltage for the high step-up boost converter

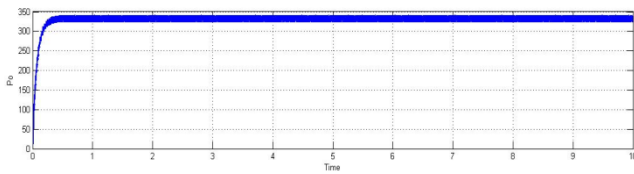


Fig.16 shows the wave form of output voltage and output current in continuous conduction mode in closed loop control of high step-up boost converter.

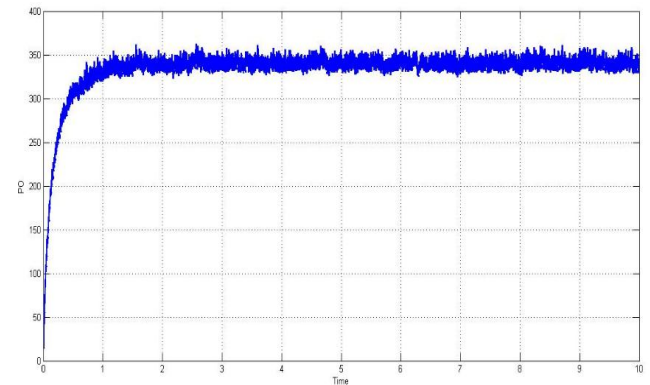


Fig.18 wave form of output power of ccm

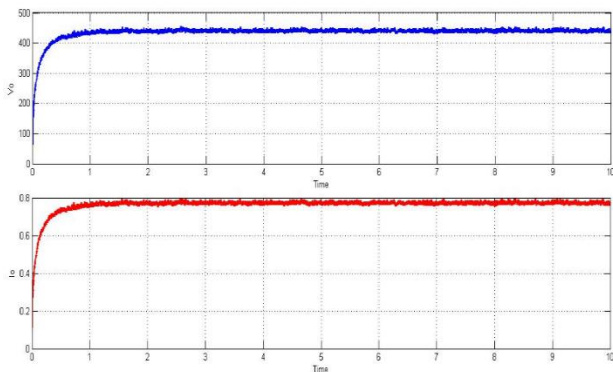


Fig.16 wave form of output voltage and output current of cc

Fig.17 shows the wave form of output voltage and inductor current in continuous conduction mode in closed loop control of high step-up boost converter.

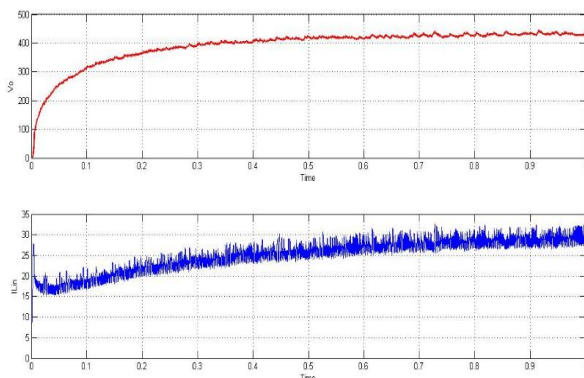


Fig.17 wave form of output voltage and inductor current of ccm

Fig.18 shows the wave form of output power in continuous conduction mode in closed loop control of high step-up boost converter.

6. CONCLUSION:

A high boost converter is successfully used as a quadratic boost converter driven by a single switch and achieved high step-up voltage gain; the voltage gain is up to 20 times more than the input. The leakage energy of coupled-inductor can be recycled, which is effectively constrained the voltage stress of the main switch S_1 and benefits the low ON-state resistance $R_{DS(ON)}$ can be selected. As long as the technology of active snubber, auxiliary resonant circuit, synchronous rectifiers, or switched-capacitor-based resonant circuits employed in converter are able to achieve soft switching on the main switch to reaching higher efficiency. The simulation of the high boost converter open loop operation in continuous conduction mode has been implemented. The results have been compared for open loop control for pulse generator and sin Pwm generator. Along with this is a closed loop operation in continuous conduction mode has been implemented and results have been plotted.

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