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High Step Up Dc-Dc Converter For Non-Conventional Energy Source

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Abstract: The demand for non-isolated high step-up dc–dc converters in applications such as dc backup energy systems for UPS, photovoltaic and fuel cell systems, and hybrid electric vehicles has been gradually increasing. This project proposes a non-isolated step-up dc–dc converter with an improved switching method. The proposed converter shows zero-voltage switching turn-on of the switches in continuous conduction mode as well as reduced turnoff switching losses using resonant PWM.As a result of the proposed switching method, the switching losses associated with diode reverse recovery become negligible even in the small duty cycle. The capacitance in the auxiliary circuit is significantly reduced compared to the pulse width modulation method. The duty cycle loss is further reduced resulting in increased step-up ratio.The result of the project is implemented in Simulation using MATLAB Simulink Software.

Key Words: Photovoltaic and fuel cell,, Step up DC-DC conversion.

I. INTRODUCTION

The demand for non-isolated high step-up dc–dc converters has been gradually increasing in accordance with the growth in dc backup energy systems for uninterruptible power system (UPS), photovoltaic systems, fuel cell systems, and hybrid electric vehicles[2]. The intensive utilization of fossil fuels causes serious green house effects on the environment In order to diminish emissions of the green-house gases, various renewable energy sources, such as fuel cells, photovoltaic (PV) systems, wind energy, tidal power, etc., have been explored and developed, especially in a smart grid[2],[3]. The renewable energy resources are clean and effective for many applications like hybrid electric vehicles, electronic controllers, and various on-grid and off-grid applications.

Energy generated by using wind, tides, solar, geothermal heat, and biomass including farm and animal waste as well as human excreta is known as non-conventional energy. All these sources are renewable or inexhaustible and do not cause environmental pollution. Moreover, they do not require heavy expenditure. The potential of non-conventional renewable energy sources is enormous as they can in principle meet many times the world's energy demand. Renewable energy sources such as biomass, wind, solar, hydropower, and geothermal can provide sustainable energy services, based on the use of routinely available, indigenous resources. A transition to renewable-based energy systems is looking increasingly likely as their costs decline while the price of oil and gas continue to fluctuate[1]. In the past 30 years solar and wind power systems have experienced rapid sales growth, declining capital costs and costs of electricity generated, and have continued to improve their performance characteristics. In fact, fossil fuel and renewable energy prices, and social and environmental costs are heading in opposite directions and the economic and policy mechanisms needed to support the widespread dissemination and sustainable markets for renewable energy systems are rapidly evolving.

It is becoming clear that future growth in the energy sector will be primarily in the new regime of renewable energy, and to some extent natural gas-based systems, not in conventional oil and coal sources. Because of these developments market opportunity now exists to both innovate and to take advantage of emerging markets to promote renewable energy technologies, with the additional assistance of governmental and popular sentiment.

The development and use of renewable energy sources can enhance diversity in energy supply markets, contribute to securing long term sustainable energy supplies, help reduce local and global atmospheric emissions, and provide commercially attractive options to meet specific energy service needs, particularly in developing countries and rural areas helping to create new employment opportunities thereIn this project, we develop a high step up dc-dc converter using boost inductor and MOSFET switches in order to step-up the dc voltage of nonconventional sources to very high value to use in various applications.

A. General Boost Converters:

The general boost converter operates at high duty cycle in order to achieve high-output voltage, the rectifier diode must sustain a short pulse current with high amplitude, resulting in severe reverse recovery as well as high electromagnetic interference problems. Also, as output voltage is increased, the switch voltage rating is increased, which increases the dominating conduction loss[2]. Moreover, a high duty cycle may lead to poor dynamic responses to line and load variations.

Various types of non-isolated high step-up dc–dc converters have been presented to overcome the aforementioned problem. Converters with coupled inductors can provide high output voltage without using high duty cycle and yet reduce the switch-voltage stress. The reverse recovery problem associated with rectifier diode is also alleviated[5]. However, they have large input current ripple and are not suitable for high-power applications since the capacity of the magnetic core is considerable.

The switched-capacitor converter does not employ an inductor making it feasible to achieve high-power density.

However, the efficiency could be reduced to allow output voltage regulation. The major drawback of theses topologies is that attainable voltage gains and power levels without degrading system performances are restricted.Most of the coupled-inductor and switched-capacitor converters are hard-switched and, therefore, they are not suitable for high efficiency and high-power applications[4]. Some soft-switched interleaved high step-up converter topologies have been proposed to achieve high efficiency at desired level of volume and power level.

Among them, the soft-switched continuous conduction mode (CCM) boost converter demonstrated reduced voltage stresses of switches and diodes and zero-voltage switching (ZVS) turn-on of the switches in CCM and zero-current switching (ZCS) turn-off of the diodes. However, a drawback of this pulse width modulation (PWM) converter is high turn-off switch losses.

B. Disadvantages Of General Boost Converters:

a. Output voltage increases with increase in the switch voltage which in turn increases the dominating conduction loss.
b. High duty cycle leads to poor dynamic responses to line and load variations.
c. It has large input current ripple and are not suitable for high-power applications.
d. Short pulse current with high amplitude at diode results in severe reverse recovery and high electromagnetic interference problems.
e. Output voltage regulation reduces the efficiency of the system.

Attaining voltage gain and power levels without degrading system performances are restricted.

This paper is organized as follows. Section I Contain introduction of project. Section II describes the proposed topology and a deeper analysis of the DC-DC converter is performed. In Section III show the main simulation and experimental results, respectively. Finally, Section VI draws the main conclusions of this paper.

II. PROPOSED SYSTEM

Generally the electrical energy from nonconventional sources will be at a very low voltage in the order few volts. Hence for any useful applications the voltage level has to stepped up using boost converters.An improved switching method, called resonant PWM (RPWM) is proposed for the soft-switched CCM boost converter in order to reduce the turn-off switching losses. Since the RPWM is performed by utilizing LC resonance in the auxiliary circuit, the capacitance is significantly reduced. Also, because of the proposed RPWM operation, the switching losses associated with diode reverse recovery become negligible even in the small duty cycle and the duty cycle loss is further reduced resulting in increased step-up ratio.

The proposed converter (see Fig.1) consists of a general boost converter as the main circuit and an auxiliary circuit which includes capacitor C, inductor L, and two diodes. Two switches are operated with asymmetrical complementary switching to regulate the output voltage. Because of the auxiliary circuit, not only output voltage is raised but ZVS turn-on of two switches can naturally be achieved in CCM by using energy stored in filter inductor Lf and auxiliary inductor L. PWM method in which the switches are turned OFF with high peak current, the proposed converter utilizes LC resonance of auxiliary circuit, thereby reducing the turn-off current of switches. Furthermore, for resonance operation, the capacitance of C is reduced, resulting in reduced volume. Also, switching losses associated with diode-reverse recovery of the proposed RPWM converter are significantly reduced.

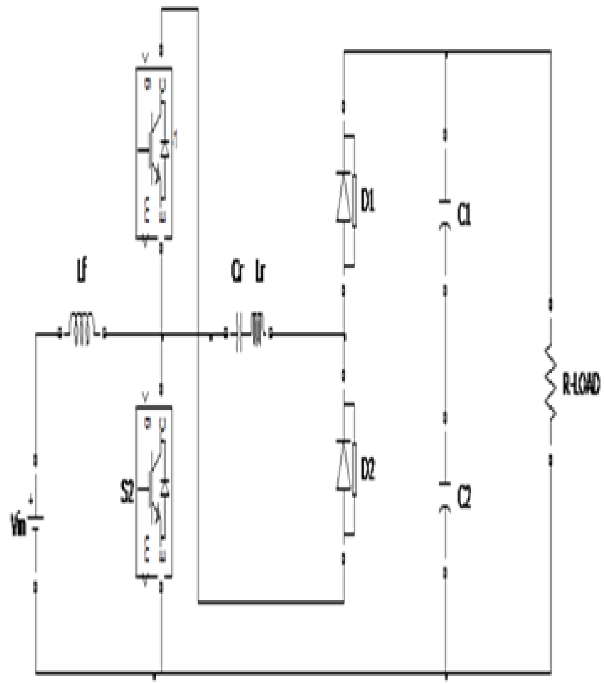

Figure 1.Proposed Topology

The generalized scheme of the proposed converter has been where it is configured with proper numbers of series and parallel connected basic cells. This leads to flexibility in device selection resulting in high-component availability and easy thermal distribution.

a) Due to the reduced operating duty, the rms current ratings of the switches are reduced by 5–15%, resulting in reduced conduction losses.
b) Due to the resonant operation, the turn-off current of switches are reduced by 25–60% and falling slopes of the diode current are reduced, resulting in significantly reduced switching losses.
c) The required capacitance of auxiliary capacitor is dramatically reduced to 1/20th, resulting in reduced volume and cost.

(a). The major drawback of theses topologies is that attainable voltage gains and power levels without degrading system performances are restricted

(b). The efficiency could be reduced to allow output voltage regulation

(c). A drawback of this pulse width modulation (PWM) converter is high turn-off switch losses. Improved switching method, called resonant PWM (RPWM) is proposed for the soft-switched CCM boost converter in order to reduce the turn-off switching losses.

System Description:

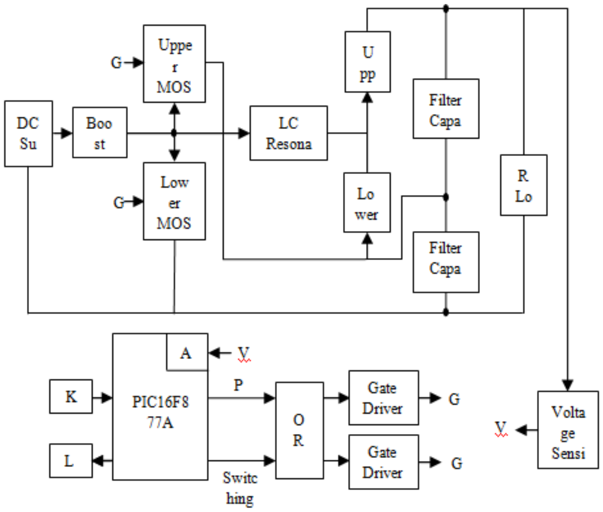

Figure : 1.1.High Step up DC-DC Converter for Non-conventional Energy Source.

Conventional boost converters employ a MOSFET switch and an LC circuit with high Q (Quality factor) in order to boost the source voltage to required level.

The voltage level has to stepped up using boost converters. MOSFETs are voltage controlled devices and have high input impedance. When enough voltage is applied to gate, the MOSFET acts as switch.

In the proposed system two MOSFET switches are employed that can be switched by complement PWM for optimum or higher step-up of source voltage. A LC resonant circuit and peaks at one frequency value the current flow resonates most strongly with the input signal.

The PWM pulses are made resonant using LC network to achieve ZVS (Zero Voltage Switching) turn-on of the switches in continuous conduction mode and ZCS (Zero Current Switching) turn-off of the switches which will greatly reduce the switching losses.

A diode is to allow an electric current to pass in one direction while blocking current in the opposite direction. A diode rectification used to convert alternating current to direct current.

Filter capacitors are capacitors used for filtering of undesirable frequencies. Capacitor is connected across the output of the rectifier in parallel with the load. The system employs a pulse generator to generate PWM pulses and switching sequence for MOSFET switches.

The system also employs a PID algorithm to achieve the desired output voltage in boost converters. For this the set value is compared with actual value and error is estimated, and the error is used to modify the ON time of PWM.

A. *Block Diagram Description:*

a. *MOSFET Switch:*

The metal–oxide–semiconductor field-effect transistor (MOSFET, MOS-FET, or MOS FET) is a transistor used for amplifying or switching electronic signals. Although the MOSFET is a four-terminal device with source (S), gate (G), drain (D), and body (B) terminals, the body (or substrate) of the MOSFET often is connected to the source terminal, making it a three-terminal device like other field-effect transistors.

Because these two terminals are normally connected to each other (short-circuited) internally, only three terminals appear in electrical diagrams. The MOSFET is by far the most common transistor in both digital and analog circuits, though the bipolar junction transistor was at one time much more common MOSFETs are voltage controlled devices and have high input impedance. When enough voltage is applied to gate, the MOSFET acts as switch. Pulse Generators are used to generate the gate pulses in MATLAB simulation.

b. *Boost Inductor:*

An Inductor, also known as a reactor is simply a coil of wire, which has many electrical properties when subjected to a magnetic field. When an electric current is passed through it, a magnetic field is created. This magnetic field helps to store the electric current for a short time, even if the supply is removed. When the magnetic field around the coil collapses, the electric current also falls off.

Thus the main two important notes of Inductors can be concluded as:

a) Inductors are used to store energy in its available magnetic field.
b) An inductor resists any change in the amount of current flowing through it.

The value of an Inductor is called Inductance and is measured in Henries. It is actually the SI unit of Inductance.

A boost converter (step-up converter) is a DC-to-DC power converter with an output voltage greater than its input voltage. It is a class of switched-mode power supply (SMPS) containing at least two semiconductor switches and at least one energy storage element, a capacitor, inductor, or the two in combination[5]. Filters made of capacitors are normally added to the output of the converter to reduce output voltage ripple. The switch is typically a MOSFET, IGBT, or BJT.

Battery powered systems often stack cells in series to achieve higher voltage. However, sufficient stacking of cells is not possible in many high voltage applications due to lack of space. Boost converters can increase the voltage and reduce the number of cells. Two battery-powered applications that use boost converters are hybrid electric vehicles (HEV) and lighting systems.

c. *LC Resonant Circuit:*

An LC electric circuit which has very low impedance at a certain frequency is called as a resonant circuit, tank circuit, or tuned circuit. Resonant circuits are often built using an inductor, such as a coil, connected in parallel to a capacitor. When connected together, they can act as an electrical resonator, an electrical analogue of a tuning fork, storing energy oscillating at the circuit's resonant frequency.

The response of the circuit to signals of different frequencies is a function of the inductance and capacitance of the circuit and peaks at one frequency value, at which the current flow resonates most strongly with the input signal.

LC circuit is an idealized model since it assumes there is no dissipation of energy due to resistance. The purpose of an LC circuit is to oscillate with minimal damping, and for this reason their resistance is made as low as possible.

An LC circuit can store electrical energy oscillating at its resonant frequency. A capacitor stores energy in the electric field between its plates, depending on the voltage across it, and an inductor stores energy in its magnetic field, depending on the current through it.

If a charged capacitor is connected across an inductor, charge will start to flow through the inductor, building up a magnetic field around it and reducing the voltage on the capacitor. Eventually all the charge on the capacitor will be gone and the voltage across it will reach zero.

An LC circuit, also called a resonant circuit, tank circuit, or tuned circuit, consists of an inductor, represented by the letter L, and a capacitor, represented by the letter C. When connected together, they can act as an electrical resonator, an electrical analogue of a tuning fork, storing energy oscillating at the circuit's resonant frequency.

d. Filter Capacitor:

Filter capacitors are capacitors used for filtering of undesirable frequencies. Capacitor is connected across the output of the rectifier in parallel with the load. The charge time of the filter capacitor must be short and the discharge time must be long to eliminate ripple action when using this filter.

A capacitor is a passive two-terminal electrical component used to store energy in an electric field. The forms of practical capacitors vary widely, but all contain at least two electrical conductors separated by a dielectric insulator one common construction consists of metal foils separated by a thin layer of insulating film. Energy is stored in the electrostatic field. An ideal capacitor is characterized by a single constant value, capacitance, measured in farads.

Capacitors are widely used in electronic circuits for blocking direct current while allowing alternating current to pass, in filter networks, for smoothing the output of power supplies, in the resonant circuits that tune radios to particular frequencies, in electric power transmission systems for stabilizing voltage and power flow, and for many other purposes.

e. Diode Rectifier:

A diode rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. The process is known as rectification. Rectifiers have many uses, but are often found serving as components of DC power supplies and high-voltage direct current power transmission systems. Rectification may serve in roles other than to generate direct current for use as a source of power.

The most common function of a diode is to allow an electric current to pass in one direction while blocking current in the opposite direction. Thus, the diode can be viewed as an electronic version of a check valve. This unidirectional behavior is called rectification, and is used to convert alternating current to direct current, including extraction of modulation from radio signals in radio receivers—these diodes are forms of rectifiers.

f. PID:

The closed loop PID controller is provided to achieve the desired output voltage. A proportional–integral–derivative controller (PID controller) is a generic control loop feedback mechanism widely used in industrial control systems. A PID is the most commonly used feedback controller. A PID controller calculates an "error" value as the difference between a measured process variable and a desired set point. The controller attempts to minimize the error by adjusting the process control inputs.

The PID controller calculation involves three separate constant parameters, and is accordingly sometimes called three-term control: the proportional, the integral and derivative values P depends on the present error, I on the accumulation of past errors, and D is a prediction of future errors, based on current rate of change. The weighted sum of these three actions is used to adjust the process via a control element such as the position of a control valve, or the power supplied to a heating element.

g. Pulse Generator:

The Pulse Generator block generates square wave pulses at regular intervals. The block's waveform parameters, Amplitude, Pulse Width, Period, and Phase Delay, determine the shape of the output waveform.Generally the electrical energy from nonconventional sources will be at a very low voltage in the order few volts. Hence for any useful applications the voltage level has to stepped up using boost converters. Conventional boost converters employ a MOSFET switch and an LC circuit with high Q (Quality factor) in order to boost the source voltage to required level.

In the proposed system two MOSFET switches are employed that can be switched by complement PWM for optimum or higher step-up of source voltage. Also the PWM pulses are made to resonate using LC network to achieve ZVS (Zero Voltage Switching) and ZCS (Zero Current Switching) which will greatly reduce the switching losses.

PID algorithm is employed to achieve the desired output voltage in boost converters. For this the set value is compared with actual value and error is estimated, and the error is used to modify the ON time of PWM.

h. Voltage Measurement:

The Voltage Measurement block measures the instantaneous voltage between two electric nodes. The output provides a Simulink signal that can be used by other Simulink blocks. The output of the system can be viewed through the scope.

i. Scope:

The Scope block displays inputs signals with respect to simulation time.If a Scope window is closed at the start of a simulation, scope data is still written to the connected Scope. As a result, if you open a Scope after a simulation, the Scope window displays the input signal or signals.

III. SIMULATION RESULTS

To obtain a nonlinear model for power electronic circuit laws. To avoid the use of complex mathematics, the electrical and semiconductor devices must be represented as ideal components (zero ON voltages, zero OFF currents, zero switching times). Therefore, auxiliary binary variables can be used to determine the state of the switches. It must be ensuring that the equations states due to power semiconductor devices being ON or OFF.

The steps to obtain a system-level modeling and simulation of power electronic converters are listed below.

a. Determine the state variables of the power circuit in order to write its switched state-space model, e.g., inductor current and capacitor voltage.

b. Assign integer variables to the power semiconductor (or to each switching cell) ON and OFF states.
c. Determine the conditions governing the states of the power semiconductors or the switching cell.
d. Assume the main operating modes of the converter (continuous or discontinuous conduction or both) or the modes needed to describe all the possible circuit operational modes.
e. Write this model in the integral form, or transform the differential form to include the semiconductors logical variables in the control vector: the converter will be represented by a set of nonlinear differential equations.
f. Implement the derived equations with "SIMULINK" blocks (open loop system simulation is then possible to check the obtained model).
g. Use the obtained switched space-state model to design linear or nonlinear controllers for the power converter.
h. Perform closed-loop simulations and evaluate converter performance.

The algorithm for solving the differential equations and the step size should be chosen before running any simulation

The High Step Up Dc-Dc Converter For Non-Conventional Energy Source is simulated using Matlab simulink and their results are presented here. The open loop and closed loop circuit model of resonant converter is shown in Fig.2. and Fig.3. respectively.

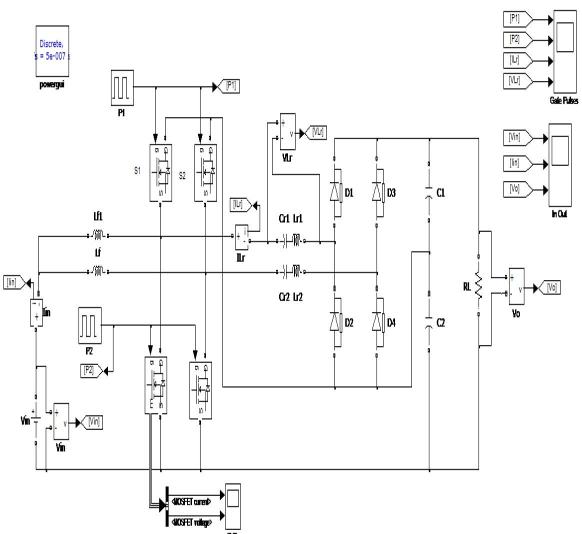

Figure 2. Open Loop Circuit

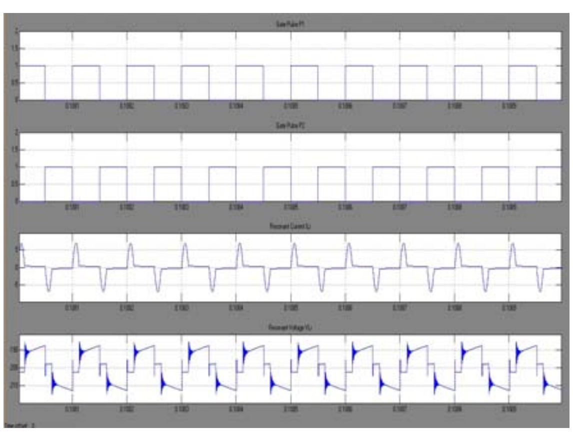

Figure 2.1. Open Loop Gate Pulses

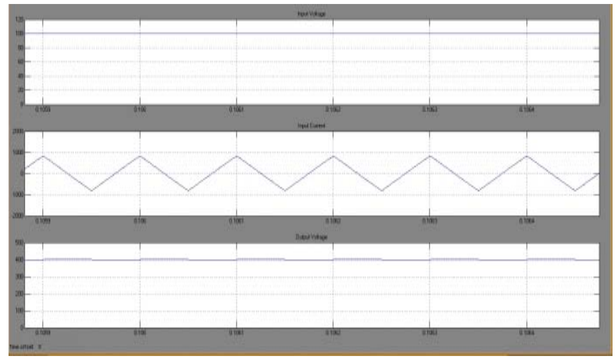

Figure 2.2. Open Loop In Out

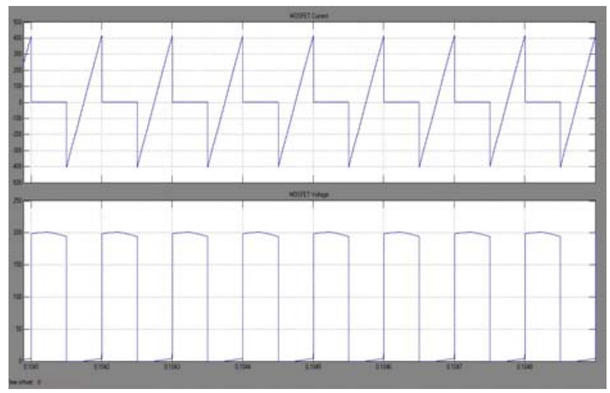

Figure 2.3. Open loop zvs

Closed loop Simulation:

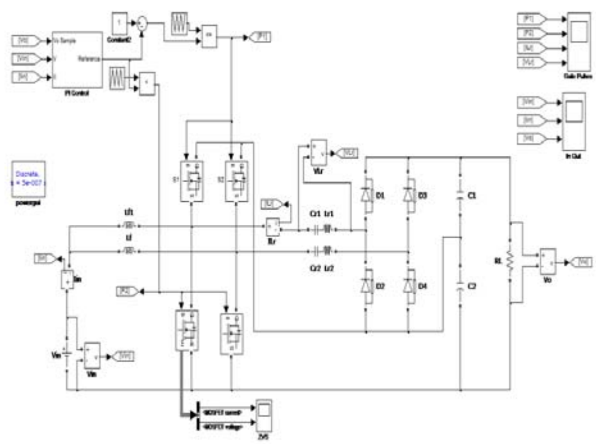

Figure 3. Closed loop circuit

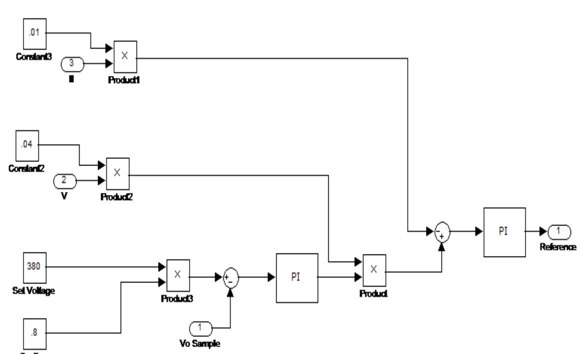

Figure 3.1. Closed loop pi control

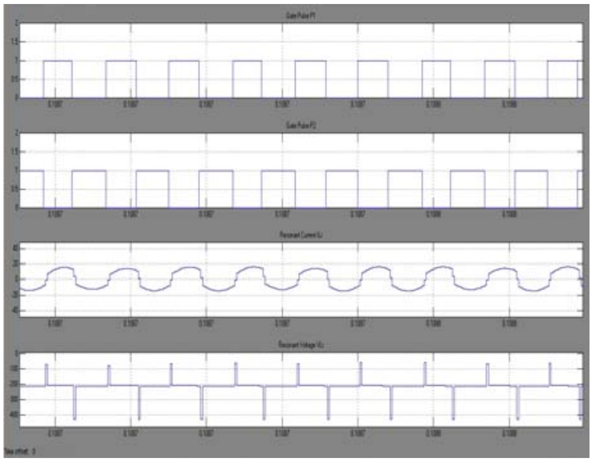

Figure 3.2. Closed loop gate pulses

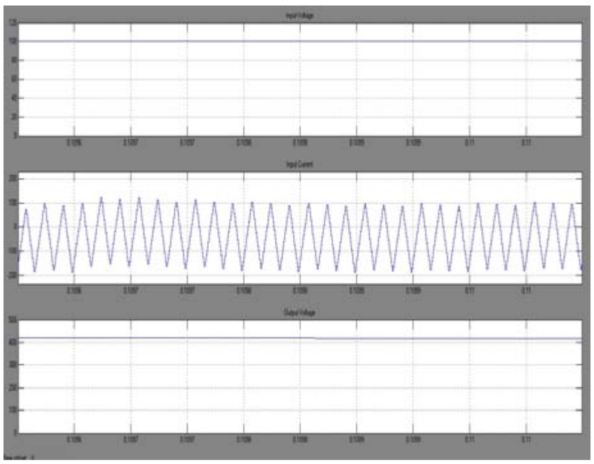

Figure 3.3. Closed loop in out

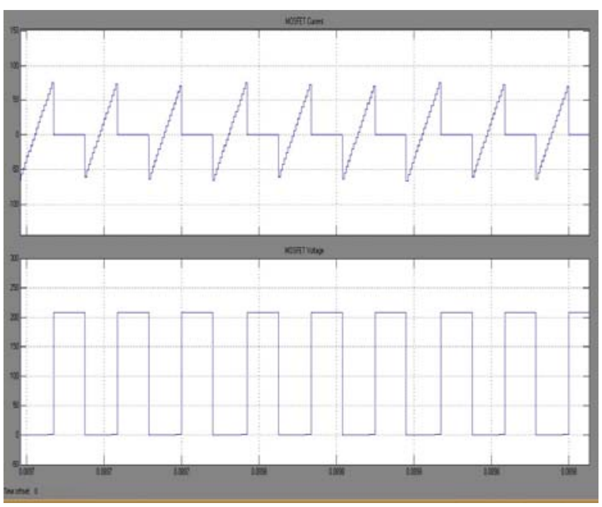

Figure 3.4. Closed loop zvs

IV. CONCLUSION

RPWM switching method has been proposed for the high step-up soft-switching dc–dc converter. The following improvements over the PWM method have been achieved:

a. The turn-off losses of the switch are significantly reduced due to reduced turn-off current
b. The auxiliary capacitor is reduced by 20-fold.
c. The switching losses associated with diode-reverse recovery become negligible small duty cycle
d. The duty cycle loss is much reduced resulting in increased step up ratio.

V. ACKNOWLEDGEMENT

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VI. REFERENCE

[1]. K. Hirachi, M. Yamanaka, K. Kajiyama, and S. Isokane, “Circuit configuration of bidirectional DC/DC converter specific for small scale load leveling system,” in Proc. IEE Power Covers. Conf., Apr. 2002, vol. 2,pp. 603–609.

[2]. Q. Zhao and F. C. Lee, “High-efficiency, high step-up DC–DC converters,” IEEE Trans. Power Electron., vol. 18, no. 1, pp. 65–73, Jan. 2003.

[3]. R. J. Wai and R. Y. Duan, “High-efficiency DC/DC converter with high voltage gain,” Proc. IEE Electr. Power Appl., vol. 152, no. 4, pp. 793–802,Jul. 2005.[5] B. Axelrod, Y. Berkovich, and A. Ioino

[4]. O. C.Mak,Y. C.Wong, and A. Ioinovici, “Step-up DC power supply based on a switched-capacitor circuit,” IEEE Trans. Ind. Electron., vol. 42, no. 1,pp. 90–97, Feb. 1995.

[5]. “Nonisolated ZVZCS Resonant PWM DC–DC Converter for High Step-Up and High-Power Applications,” Yohan Park, Byoungkil Jung, and Sewan Choi, Senior Member, IEEE IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 27, NO. 8, AUGUST 2012.

[6]. “DC-DC CONVERTERS VIA MATLAB/SIMULINK” Mohamed Assaf, D. Seshsachalam, d. Chandra, r. K. Tripathi, Electrical Engineering Department, Motilal Nehru National Institute of Technology Allahabad, Utter Pradesh-211004, INDIA.