DESIGN & IMPLEMENTATION OF SOFT SWITCHING DC-DC CONVERTER WITH HIGH VOLTAGE GAIN FOR HIGH POWER APPLICATION

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Abstract - **A zero voltage switching (ZVS) dc–dc converter with high voltage gain is proposed. It consists of a ZVS boost switch cell converter stage and a ZVS half-bridge converter stage with resonant converter and all these stages are merged into a single stage. The ZVS boost converter stage provides a continuous input current and ZVS operation of the power switches. The ZVS half-bridge converter stage provides a high voltage gain. The principle of operation and system analysis are presented. The design of the half-bridge converter stage can be focused on high voltage gain. Therefore, high voltage gain is easily obtained. ZVS operation of the power switches reduces the switching loss during the switching transition and improves the overall efficiency.**

Index Terms - **Boost converter, coupled inductor, high voltage gain, reverse recovery, zero-voltage switching (ZVS).**

I. INTRODUCTION

DC–DC converters with high voltage gain are required in many industrial applications such as the front-end stage for the renewable and green energy sources including the solar arrays and the fuel cells, the power systems based on battery sources and super capacitors.

IN dc–dc converters with high voltage gain, there are several requirements such as high voltage gain, low reverse-recovery loss, and soft-switching characteristic, low-voltage stress across the switches, electrical isolation, and continuous input current and high efficiency. In order to meet these requirements, various topologies are introduced. In order to extend the voltage gain, the boost converters with resonant circuit is proposed.

The voltage gain is extended but continuous input current characteristic is lost and the efficiency is degraded due to hard switching of power switches. Their switching frequencies are limited due to the hard-switching operation.

In order to increase the efficiency in various soft-switching techniques are suggested. Generally, there are tradeoffs between soft-switching characteristic and high voltage gain. It is because an inductor that is related with soft-switching limits the voltage gain.

In order to solve these problems, a zero-voltage-switching (ZVS) dc–dc converter with high voltage gain is proposed. As shown in Fig. 1, it consists of a ZVS boost converter stage to make the input current continuous and provide ZVS functions and resonant circuit for impedance matching between load and source and a ZVS half-bridge converter stage to provide high voltage gain. Since single power processing stage can be a more efficient and cost-effective solution, the stages are merged and share power switches to increase the system efficiency and simplify the structure.

Since both stages have the ZVS function, ZVS operation of the power switches can be obtained with wider load variation. Moreover, due to the ZVS function of the boost converter stage, the design of the half-bridge converter stage can be focused on high voltage gain. Therefore, high voltage gain is easily obtained. ZVS operation of the power switches reduces the switching loss during the switching transition and improves the overall efficiency. The theoretical analysis is verified by a 100W experimental prototype with 24–393 V conversion.

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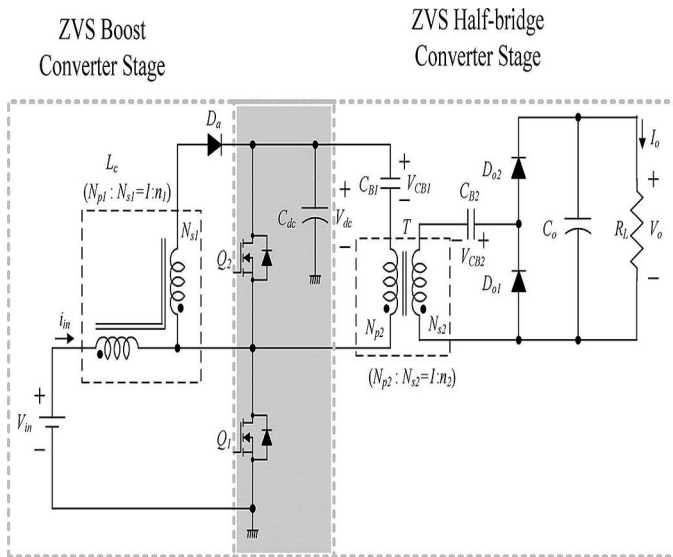**Conventional dc-dc converter circuit diagram**

Fig convntional soft-switching dc–dc converter with high voltage gain

The equivalent circuit of the proposed converter is shown in Fig.. The ZVS boost converter stage consists of a coupledinductor Lc , the lower switch Q1 , the upper switch Q2 , the auxiliary diode Da , and the dc-link capacitor Cdc. The diodes DQ1 and DQ2 re present the intrinsic body diodes of Q1 and Q2. The capacitors CQ1 and CQ2 are the parasitic output capacitances of Q1 and Q2 . The coupled inductor Lc is modeled as the magnetizing inductance Lm1 , the leakage inductance Lk1 , and the ideal transformer that has a turn ratio of 1:n1 (n1 = Ns 1/Np 1).

The ZVS half-bridge converter stage consists of a transformer T, the switches Q1 and Q2 , the output diodesDo1 andDo2 , the dcblocking capacitors CB1 and CB2 , and the output capacitor Co . The transformer T is modeled as the magnetizing inductance Lm2 , the leakage inductance Lk2 , and the ideal transformer that has a turn ratio of 1:n2 (n2 = Ns 2/Np 2). The theoretical waveforms of the proposed converter are shown in Fig. The switches Q1 and Q2 are operated asymmetrically and the duty ratio D is based on the switchQ1 . The operation of the proposed converter in one switching period Ts can be divided into seven as shown in Fig. 4. Just beforeMode 1, the upper switch Q2, the auxiliary diode Da , and the output diode Do1 are conducting. The magnetizing current im1 of Lc arrives at its minimum value Im12 and the

auxiliary diode current iDa arrives at its maximum value IDa. The current iL has its maximum value IL 1 .
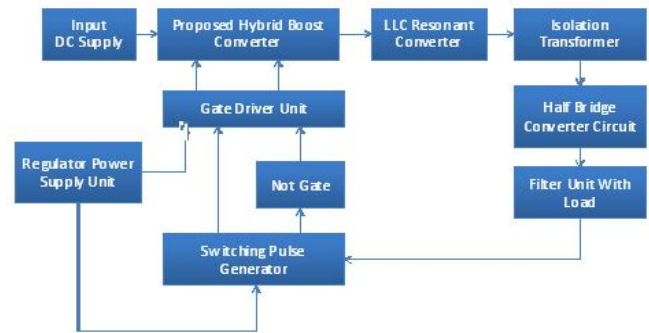
FUNCTIONAL BLOCK DIAGRAM

Fig Proposed functional block diagram

The input source is a DC supply. Then the hybrid boost converter circuit are used to high power voltage produced. But the switching losses and voltage stress are reduced. The resonant circuit is produced by the high frequency. So the isolation transformer is used to boost the voltage and high frequency transformer. Next the half bridge rectifier circuit, it is used to AC voltage into DC voltage. The rectifier is improve the double of the voltage, the losses is reduced the filter. So the output is high of the circuit. Since both stages have the ZVS function, ZVS operation of the power switches can be obtained with wider load variation. Moreover, due to the ZVS function of the boost converter stage, the design of the half-bridge converter stage can be focused on high voltage gain. Therefore, high voltage gain is easily
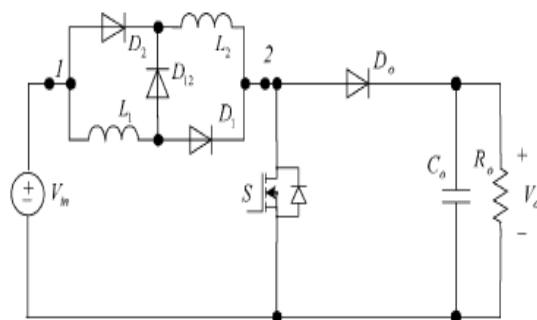
HYBRID BOOST CONVERTER

Fig Hybrid boost converter

The hybrid boost switching blocks are inserted in a classical boost converter to give the hybrid step-up power supplies respectively. For reducing the output current ripple, an output inductor is inserted after Voltage second balance on the inductors lead to,

$$V_o = \frac{1+D}{D_1} V_{in}$$

hybrid converters Hybrid dc–dc PWM step-up converter with switching structure. A dc gain (1=+D) times bigger than that of a classical boost converter is obtained. The circuit was studied in detailed. Where experimental results proved the expected performances. The input inductor in a classical boost converter was just replaced by the two inductors of in the new hybrid converter. A unified   method for developing hybrid converters with a high step-down/up conversion voltage ratio was proposed.

The topologies and formulas of the dc gain have been deducted, a detailed   analysis and discussion of practical aspects of every one of the new converters being left for other papers. The new present a similar complexity with available quadratic converters (or one element less for some of the new converters similar voltage stresses on the transistors and diodes, and similar conversion ratio as the   quadratic converters (for some values of the duty cycle, some of the quadratic converters have the edge, for other values, the new hybrid   converters have a steeper step-down/up dc voltage ratio). The main advantage of the new converters is their lower energy in the magnetic elements, what leads to weight, size and cost saving for the inductors, and thus for the power supply, and less conduction losses, what leads to a better efficiency. of the new converters being left for other papers

The new hybrid   converters   present a similar complexity with available quadratic converters (or one element less for some of the new converters), similar voltage stresses on the transistors and diodes, and similar conversion ratio as the quadratic converters (for some values of the duty cycle, some of the quadratic converters have the edge, for other values, the new hybrid converters have a steeper step-down/up dc voltage ratio).

The main advantage of the new converters is their lower energy in the magnetic elements,

what leads to weight, size and cost saving for the inductors, and thus for the power supply, and less conduction losses, what leads to a better efficiency.

Feature of proposed Hybrid DC-Dc converter

> High efficiency.
> Reduced size & weight.
> Simpler structure & control.
> Provide high voltage gain with out entre switch duty cycle.
> Lower switching stress on the semiconductor devices so as to reduce the cost switch conduction is turn on losses.
> Ripple free continuous output & input current.

PROPOSED CIRCUIT DIAGRAM

This paper consists of a ZVS hybrid boost converter circuit, half bride LLC resonant circuit and half bridge rectifier circuit are arranged by the soft switch DC-DC converter. ZVS operation of the power switches. ZVS hybrid boost stage to make the input current continuous and ZVS half bridge converter stage provide high voltage gain.
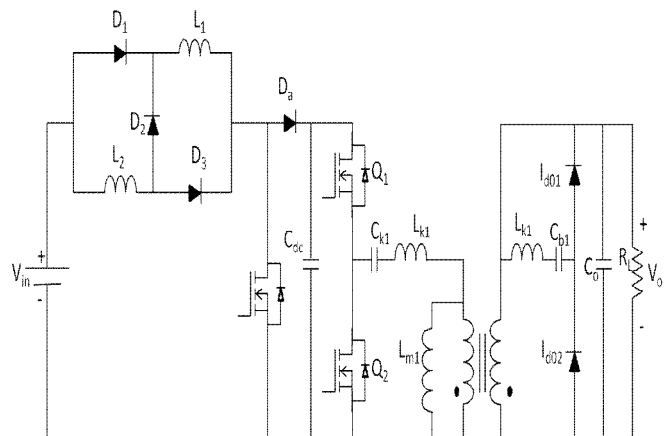

Fig. Propose Soft Switching dc –dc converter with high voltage gain

Since single power processing stage can be a more efficient and cost-effective solution, both stages are merged and share power switches to increase the system efficiency

and simplify the structure. Since both stages have the ZVS function, ZVS operation of the power switches can be obtained with wider load variation. Moreover, due to the ZVS function of the boost converter stage, the design of the half-bridge converter stage can be focused on high voltage gain. Therefore, high voltage gain is easily obtained. ZVS operation of the power switches reduces the switching loss during the switching transition and improves the overall efficiency.

The boost converter produced a improve the output voltage, then the resonant switch are used to reduce the switching losses but the frequency improved by this resonant switches. It consists of the isolation transformer used to ac-dc conversion, with acting the high frequency transformer. The last stage is the half bridge rectifier converter, it is used for secondary said transformer output is ac voltage. Therefore change the ac voltage into the dc voltage because the output is the dc voltage. So rectifier are used. The capacitor are used to filter circuit, the output is filtering and reduces the losses of the output circuit. So the output side is improved with   high voltage gain and high efficiency.

The new hybrid converters present a similar complexity with available quadratic converters (or one element less for some of the new converters), similar voltage stresses on the transistors and diodes, and similar conversion ratio as the quadratic converters (for some values of the duty cycle, some of the quadratic converters have the edge, for other values, the new hybrid converters have a steeper step-down/up dc voltage ratio). The main advantage of the new converters is their lower energy in the magnetic elements, what leads to weight, size and cost saving for the inductors, and thus for the power supply, and less conduction losses, what leads to a better efficiency.

Comparision of conventional and proposed topology

In order to extend the voltage gain, the boost converters with coupled inductors are proposed in the converter.   The voltage gain is extended but continuous input current characteristic is lost and the efficiency is degraded due to hard switching of power switches. In a step-up converter based on a charge pump and coupled inductor is suggested. Its voltage gain is around 10 but its efficiency is not high enough due to the switching loss. In a high-step-up converter with coupled inductors is suggested to provide high voltage gain and a continuous input current. However, its

operating frequency is limited due to the hard switching of the switches. The converters suggested have a similar drawback. Their switching frequencies are limited due to the hard-switching operation. In order to increase the efficiency and power density, soft-switching technique is required in dc–dc converters. In   arious soft-switching techniques are suggested. Generally, there is a tradeoff between soft-switching characteristic and high voltage gain. It is because an inductor that is related with soft-switching limits the voltage gain. In order to solve these problems, a zero-voltage-switching (ZVS) dc–dc converter with high voltage gain is proposed. As shown in Fig, it consists of a ZVS boost onverter stage to make the input current continuous and provide ZVS functions and a ZVS half-bridge converter stage to provide high voltage gain. Since single power processing stage can be a more efficient and cost-effective solution, both stages are merged and share power switches to increase the system efficiency and simplify the structure.

Feature of the soft switching DC-DC converter

- Soft switching characteristics
- Low-voltage stress across the switches
- Electrical isolation
- Low reverse recovery loss
- Continuous input current
- High efficiency
- High voltage gain

Application of proposed DC-DC Converter

DC–DC converters with high voltage gain are required in many industrial applications such as the front-end stage for the renewable and green energy sources including the solar arrays and the fuel cells, the power systems based on battery sources and super capacitors. In dc–dc converters with high voltage gain improved.
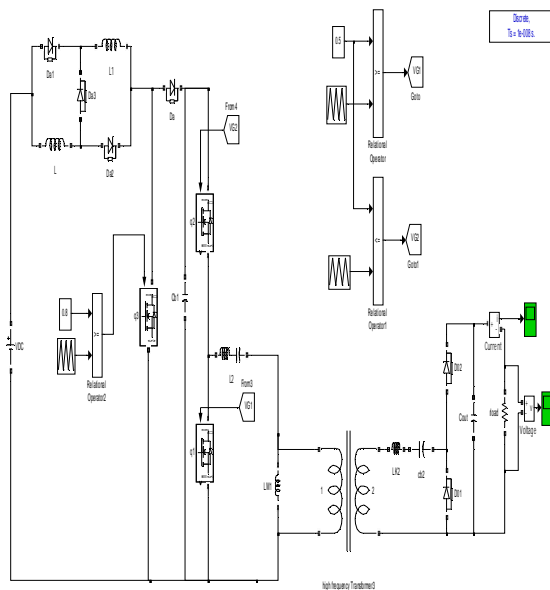
Simulation diagram and results for hybrid boost dc-dc converter

The circuit diagram of half bridge zero voltage hybrid boost converter DC-DC converter is shown below. In this circuit, the voltage and current waveforms are measured
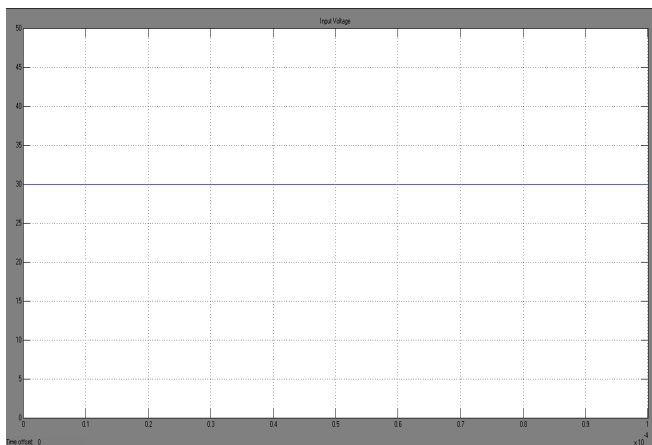
with voltage and current measurement block. Voltage is measured for input of the dc source . The dc output voltage is measured using the discrete mean block.
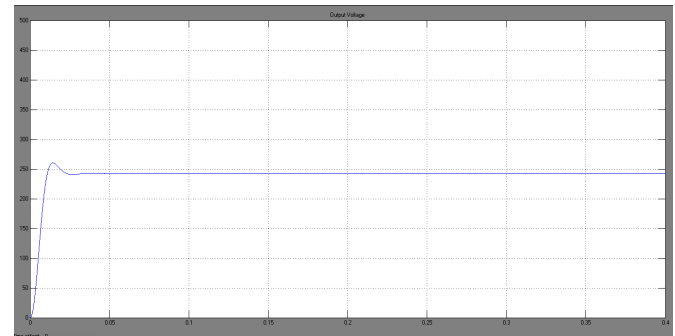
SIMULATION

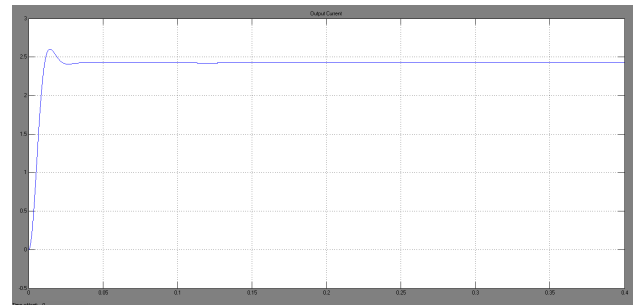### SIMULATION OF OPEN LOOP CONTROL OF THE DC-DC CONVERTER CIRCUIT
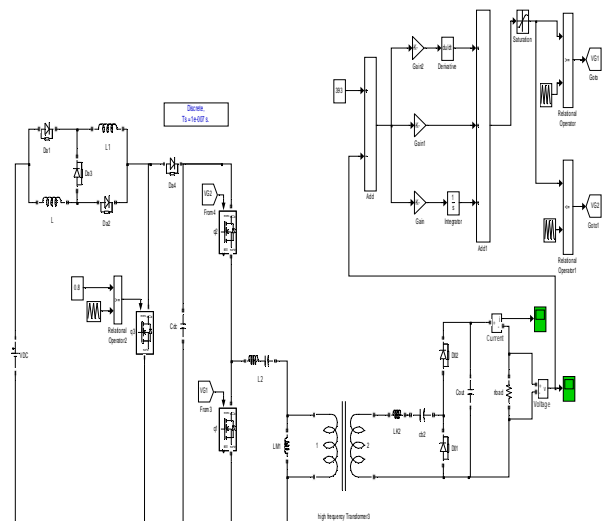

Simulation open loop input voltage waveform

SIMULATION OPEN LOOP OUTPUT VOLTAGE WAVEFORM

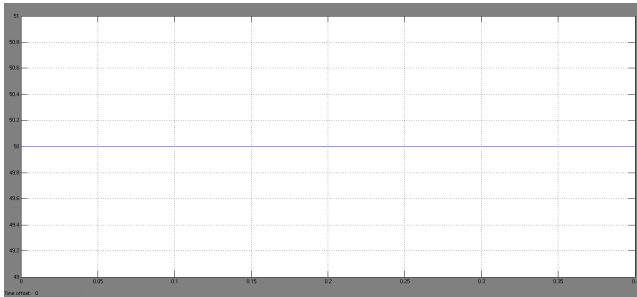**Simulation open loop output current waveform**

### SIMULATION CLOSED LOOP CONTROL OF THE DC-DC CONVERTER CIRCUIT

The circuit diagram of half bridge zero voltage hybrid boost converter DC-DC converter is shown below. In this circuit, the voltage and current waveforms are measured with voltage and current measurement block. Voltage is

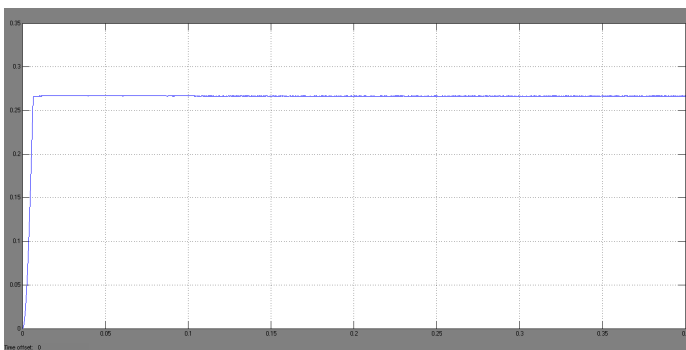measured for input of the dc source . The dc output voltage is measured using the discrete mean block.

Simulation closed loop input voltage waveform

SIMULATION CLOSED LOOP OUTPUT VOLTAGE WAVEFORM
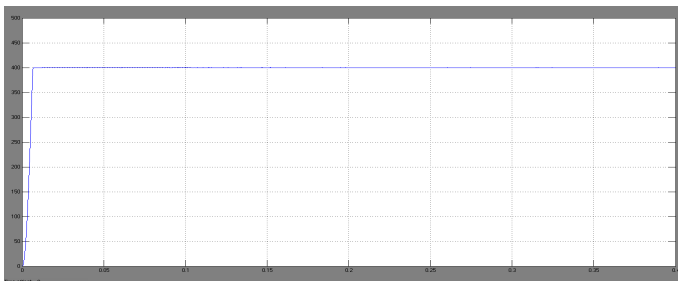
Simulation closed loop output current waveform

Conclusion

A new novel soft switching scheme is designed and simulated with a feedback control. PI Controller is used for feedback control. We simulated the soft switching technique and achieved the low stress and less switching loss in the converter. The linear PI controller was designed based on

frequency response of the boost converter using frequency response technique. The simulated results shows that the only switch used in this converter is switched ON at zero current and switched OFF at zero voltage. The output voltage is boosted and it is constant. The output is high voltage gain achieved It reaches the steady state vale within several micro seconds.

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