

NOVEL DESIGN OF IMPROVED VOLTAGE GAIN RESONANT DC-DC CONVERTER FOR AUTOMOTIVE PURPOSE

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Abstract: The main drawback of conventional power take-off system is inefficient with more fuel usage. Hence power take-off system is made electronic and it is used in specialty vehicle application. This requires resonant DC-DC converter with high voltage gain which is implemented in this work. The converter model uses zero voltage switching in switching devices and zero current switching in rectifier operation to reduce the conduction loss and improve the efficiency of the converter. In order to achieve soft switching technique and extended voltage control series resonant tank is used. The transformer requirement and the stress on the circuit is reduced by adopting interleaved step-up methodology. The output voltage is regulated by varying the duty ratio with respect to input voltage range. The experimental outcome verifies the design and operation of the circuit. An improved efficiency of 95% has been attained in this model and thus making it suitable for electric vehicle application.

Keywords: ZVS: zero voltage switching, ZCS: zero current switching, ePTO: electronic power take-off.

1. Introduction

In several applications like automotive systems Power take and off (PTO) system which refers to the system that retrieves or takes power from engine places such that the inner combustion engine (ICE) the shaft to drive vehicle accessories. Power takeoff system is wide employed [1] in the specialty vehicles, like utility truck, tractors, construction vehicles, etc. In [1] these vehicles, there are several electrical loads to be driven by the power takeoff system so the shaft of the ICE is usually connected to a generator. [1] Some of the key challenges of this power takeoff [1] system include low potency, high consumption of the fuel within the [1] ICE running at idle, system maintenance and lifetime. The processed Electrification during this power takeoff system may be a sensible resolution to address these challenges. [1] With the event of energy storage system and power electronics technology, now it's potential to understand the electrical power take-off (ePTO) system in such vehicles and its application are often expanded to

alternative kinds of vehicles like automobile, long haul trucks, transit bus, etc. that have many electrical accessory masses.

The aim of ePTO system is victimization electric power supply like battery and electrical device to drive the vehicle electrical accessories whereas the ICE solely provides propulsion to the wheel. it'll greatly cut back the fuel consumptions at the work site. The ePTO system desires power converter that will transfer the lower voltage power from battery or electric cell to drive the high voltage electrical masses. In this method gain of high voltage increase DC to DC converters became a vital a part of such application. A new topology for high voltage gain DC-DC converter with high input current introduced in this paper. [1] In this topology interleaved configuration helps the circuit to achieve a low current ripple and reduces the current stress of the device. Transformer turns-ratio and current stress are relatively low. [1] The transformer leakage inductance acts as the resonant inductor so [1] that it helps to relieve the voltage spike issue as well as achieve a high efficiency. Zero Voltage Switching and Zero Current Switching can be achieved therefore in order to maintain the over the entire load range which tends maintain a efficiency at maximum range

2. Design Ideas

B. Lequesne et al, the price of the auto has broadened records. Electric and cross breed automobiles are simply excellent a bit a chunk of it, though right now the most discernible and the only getting the most fixation in fashionable media. This paper will give attention to the unwinding of the story, i.e., components of transportation zap as opposed to pass breed or totally electric powered impetus approaches. Cutting-edge boost (ultimate 10-20 years) and cutting-edge paintings at the jolt of street transport, from case to powertrains, will be checked on with a factor of convergence on electromechanical frameworks. within the method, the various difficulties engineers have triumph over or have yet to decide may be featured, along these traces representing the distinct elite strategies electrical designing is making its test in conveying greater

development, extra viable, more at ease, and first-rate way of private transportation [1].

F. Shang, M. Krishnamurthy, and A. Isurin, electric electricity takes-off frameworks in vehicle require the gadget of low voltage excessive gift improve up DC-DC converter with an over the top voltage accumulate. Analysts have assessed enhancements for prime affectivity and minimum effort outlines. In this paper, a unique topology is suggested that has the potential of giving a high voltage increase over an expansive scope of yield power. It moreover has fewer extras and cuts stretch. Critical operation of the topology had been presented and checked with the aid of activity in PSIM [2].

X. Kong and A. Khambadkone, an interleaved contemporary-sustained complete scaffold (ICFFB) dc-dc converter is proposed on this paper has low input display swell to satisfy the gasoline cell phone wishes. Via interleaving indifferent CFFB converters with parallel data and association yield association, each data modern-day swell and yield voltage swell may be decreased. Additionally, the scale of the appealing additional gadgets and gift worry of the semiconductor units at the input function are furthermore delivered down. So additionally, littler voltage score frill can be used on the yield aspect. Only a single automatic signal processor microcontroller is utilized to create section moved door flags and to put in compel a fell superior manage process. The great parts of the proposed converter are excessive affectivity, little inactive thing estimation, and little information show swells [3]. H.-L. Do et al, the manager of the proposed converter is completed with the awry heartbeat width tweak approach. The proposed converter accomplishes 0-voltage changing (ZVS) of all power switches. 0-current replacing (ZCS) of yield diodes can likewise be finished. The proposed converter can outfit excessive-voltage accomplish and the voltages over the semiconductor instruments are simply cinched. Consistent kingdom examination of the proposed converter is given. A lab version of the proposed converter is produced, and its exploratory results are accommodated validation [4].

[1]W. Chen, X. Wu, L. Yao, W. Jiang, and R. Hu, the fast development of gigantic scale sustainable force [2]sources and HVDC matrix, it is a promising alternative to accomplice the inexhaustible energy resources to the HVDC lattice with an unadulterated dc method, in which excessive-existence high-voltage assignment up dc-dc converters are the vital factor tools to transmit the electric life. This paper proposes a resounding converter which is affordable for framework connected sustainable electricity sources. The converter can accomplish inordinate voltage get making usage of a LC parallel resounding tank. it is described with the manual of zero-voltage-replacing (ZVS) turn-on and nearly ZVS kill of maximum critical switches comparable to zero-showcase turning turn-off of

rectifier diodes; additionally, the similar voltage fear of the semiconductor devices is downsize than other complete boost up converters. The operation statute of the converter and its complete parameter preference is offered on this paper. The operation widespread of the proposed converter has been productively permitted by means of using reenactment and test final results [5].

3. Evaluation Index System

A spic and span competitor topology for pinnacle voltage accomplish task up DC-DC converter the use of thunderous innovation has been proposed. also to its excessive voltage get and extensive enter run, it furthermore brings the blessings of low info display swell, diminishing modern worry in replacing devices and transformer, ZVS in lifestyles MOSFETs and ZCS within the rectifier diode operation over the complete load run and inordinate productiveness.

In this topology interleaved arrangement encourages the circuit to advantage a low present swell and decreases the prevailing worry of the tool. Transformer turns-share and present anxiety are surely low. The transformer spillage inductance is going about because the thunderous inductor all collectively that it diminishes the voltage spike issue inside the same class as secure an over the top productiveness. ZVS and ZCS can likewise be executed over the complete load variety to preserve up an inordinate talent.

Advantages are,

- ✓ In case of current in terms of ripple current is very low.
- ✓ Capable of reducing the stress current in the electrical appliances.
- ✓ The ratio between stress current and no of turns in transformer ratio are comparatively less.

4. System Design

A. Resonant Converter

A type contains power converter method which is obtained by resonant converter this is a type of electric power converter which contains a related network consist of inductors integrated with capacitors this is called a "resonant tank", tuned to resonate at a specific frequency. These convertor has many applications in electronics and in integrated circuits.

There are multiple types of Resonant Converter: -

1. Inverter with series resonant
2. Inverter with Parallel resonant
3. Type named Class E Resonant Converter
4. Type named Class E Resonant Rectifier
5. Resonant Converter with Zero Voltage Switching
6. Dual Quadrant Zero Voltage Switching Resonant Converter
7. Resonant dc-link inverter

B. DC-DC converter (Chopper)

Chopper makes use of high speed to attach and disconnect from a supply load. A constant DC voltage is utilized intermittently to the supply load by way of always triggering the vigor change ON/OFF. The interval of time for which the vigor switch stays ON or OFF is known as the choppers ON and OFF state occasions, respectively.

Choppers are more commonly utilized in electric cars, conversion of wind and solar energy, and DC motor regulators.

Classification of Choppers – Depending on the voltage output, choppers are classified as

- Step Up chopper (boost converter)
- Step Down Chopper (Buck converter)
- Step Up/Down Chopper (Buck-boost converter).

1) Circuit Diagram

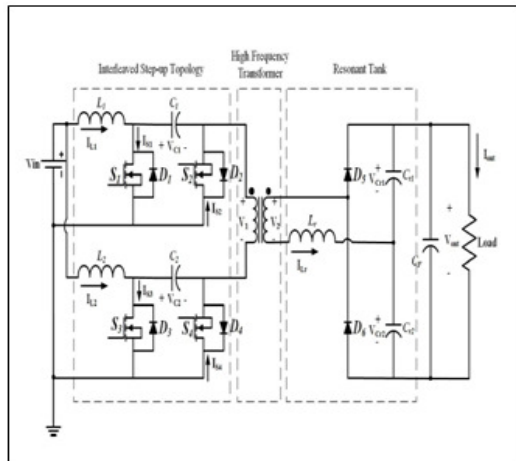


Figure 1. Resonant DC-DC converter for high voltage gain

C. Operation of Proposed Converter

The operations of the proposed converter are explained as follows with different modes of operations.

1) Operation Modes

a) For $D = 0.5$

Interval 1 ($t_0 - t_1$): At time t_0 , present within the resonant inductor or gradually changes from zero in the optimistic direction. For this interval, S_1 and S_4 are switched to ON condition. The detailed description shown in the figure 2(a). for the value of $D=0.5$. The current in inductor L_1 rises via S_1 to retailer vigor, while in L_2 present in L_2 via S_4 . C_1 is hooked up to the transformer most important side via S_1 and S_4 . It presents vigor via the design of resonant circuit that weight and the predominant aspect voltage $V_1 = VC_1$.

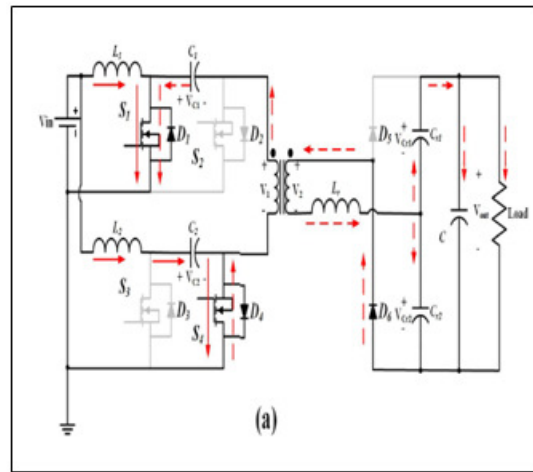


Figure 2. (a) For $D = 0.5$

At this stage which means end of specific interval, the resonant present in L_r attains level 0 at t_1 .

Interval 2 ($t_1 - t_2$): At instant t_1 , S_1 and S_4 are turn off and S_2 and S_3 z switches are ON. The systematic design of equivalent circuit is described in figure 2 (a). The designed circuit works similarly to given interval 1. The resonant current i_{Lr} which has certain limit up to zero interval which goes to the negative half cycle and finish to zero at the end stage of the interval.

a) For $D < 0.5$

For $D < 0.5$ operations, Fig. show that there is a period when the resonant current i_{Lr} is zero. In this mode, the resonant current i_{Lr}

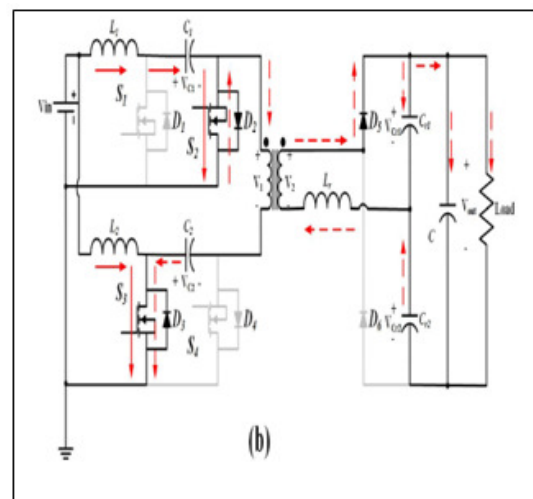


Figure 3. (b) For $D < 0.5$

The following mode of conduction provides discontinuous mode of operation. The conduction mode depends up on three periodic definitions, T_{on} is the time period this is when the primary side voltage is not zero, while the time T_0 is the time when the transformer voltage is zero. In this mode, $T_{on} = DT_s$ and $T_0 = (0.5D)T_s$. Time T_1 is defined as the ratio of time period when the transformer voltage zero for resonant current decay to the zero during specific time period T_0 . There are six intervals in this operating mode. Using this symmetrical operation of the circuit, only the positive cycle is analyzed.

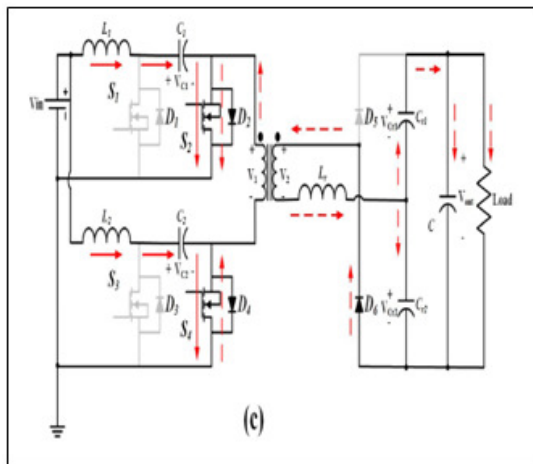


Figure 4. (c) For $T_{on} = DT_s$

The analyzed Interval 1 between the time ($t_0 - t_1$): During this interval, the circuit operates similarly to the interval 1 for $D = 0.5$ operation mode. S_1 and S_4 are turned on. The resonant current i_{Lr} rises from zero but ends at instant t_1 instead of going back to zero because T_{on} is less than half of the resonant cycle.

Interval 2 ($t_1 - t_2$): At immediate t_1 , S_1 is off and S_2 is grown to become on. Throughout this interval, S_2 and S_4 are on together. The identical circuit is shown. The current in inductor L_1 and L_2 costs C_1 and C_2 respectively at the same time the transformer foremost facet is shorted through S_2 and S_4 . Resonant present in i_{Lr} decays so this tends to be faster and attains time interval during this interval and returns to zero after time interval T_1 (mentioned by way of on the spot t_2).

Interval 3 ($t_2 - t_3$): S_2 and S_4 [1] these states are already in ON state present in inductor L_1 and L_2 performs charging state C_1 and C_2 . Current flow is ideal in the resonant which means no current in resonant tank in the course of [1] this period. The burden present is furnished by using the filter capacitors.

For $D > 0.5$, as shown in Fig 5, the resonant present i_{Lr} can be in DCM mode just like $D < 0.5$ mode. On this mode, $T_{on} = (1 - D) T_s$ and $T_0 = (D -$

$0.5) T_s$. There are additionally six intervals in this operation mode and interval 1 and 4 are the equal as $D < 0.5$ modes.

At Interval 2 ($t_1 - t_2$): At instantaneous t_1 , S_4 is become off and S_3 is become on. During this interval, S_1 and S_3 are turned on concurrently. The systematic equivalent circuit is shown in Fig 5. Both L_1 and L_2 retailer vigor from the source even as C_1 and C_2 are connected in series to the transformer as primary part and it sees zero internet voltage.

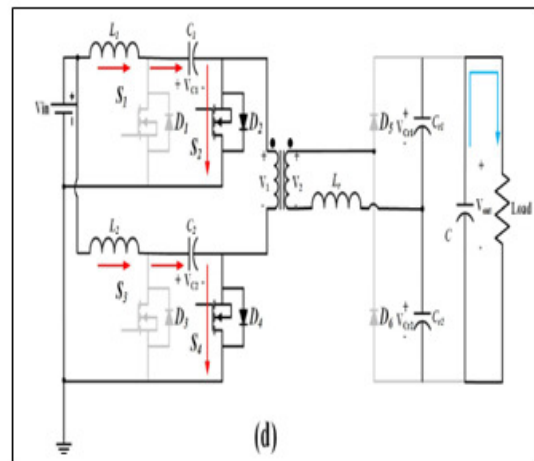


Figure 5. (d) For $D > 0.5$

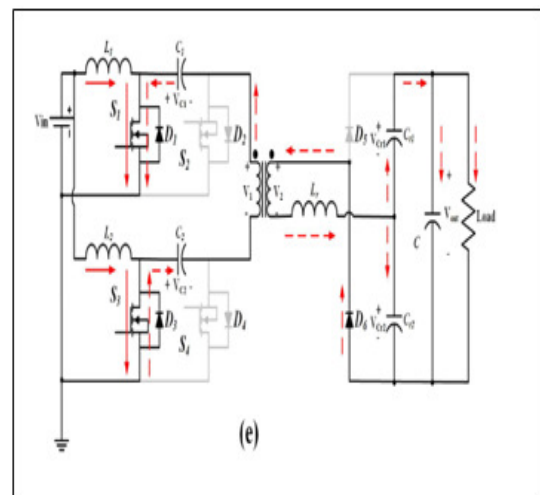


Figure 6. (e) At $t=T_1$

The resonant current returns to zero after time T_1 .

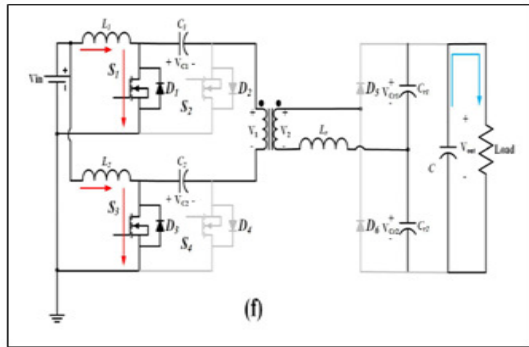


Figure 7. (f) At interval (t_2 - t_3)

Interval (t_2 - t_3): S1 and S3 maintain turn on and at the same time the resonant current stays at zero. The weight present is offered by way of the filter capacitors.

5. Architecture Diagram and Simulations

A. Proposed Circuit

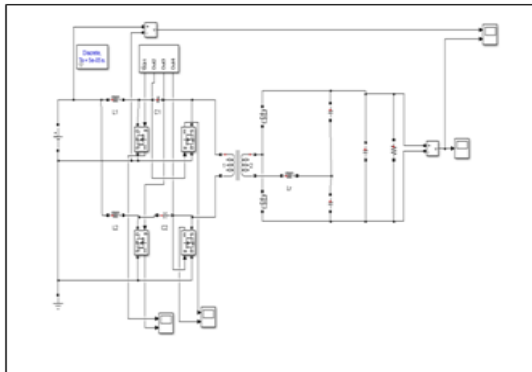


Figure 8. Simulation of resonant DC-DC converter topology for high voltage gain.

B. Output Voltage Waveform

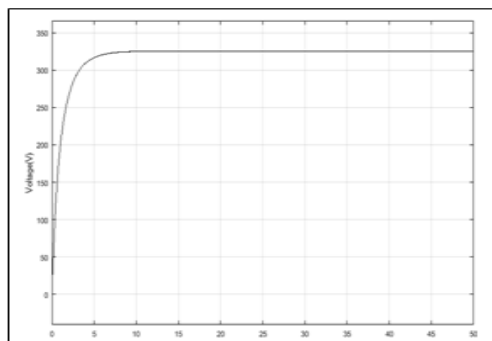


Figure 9. Output voltage waveform

C. Expected Input and Output

Input given to the circuit is 24V DC.
Output got is 350V DC

D. Advantages

- ✓ Induces less and very low ripple current.
- ✓ Device strain current is reduced
- ✓ Comparatively low transformer turns to current stress ratio.

E. MOSFET Gate Driver

The high and Low Side Driver (IR2112) is an excessive voltage and current, high speed energy MOSFET and IGBT driver with unbiased excessive and [4] low side referenced output channels. Proprietary HVIC and latch immune CMOS technologies enable ruggedized [4] monolithic development. Logic inputs are suitable with common CMOS or LSTTL outputs, all the way down to 3.3V good judgment. The final efficient output for drivers for feature with a high pulse that present buffer stage designed for minimal driver go [4] conduction. The mentioned propagation delays are specifically matched with reference also tends to simplify use in excessive frequency functions. [1] The floating channel can be used to drive N-channel vigor MOSFET or IGBT within the excessive part configuration which operates as much as required volts in between 400v to 600v.

The motive force circuit is used to pressure the bi-directional converter switches where in this assignment the converter acts as a shunt energetic filter (2-quadrant) for harmony vigor factor operation and the dc voltage legislation.

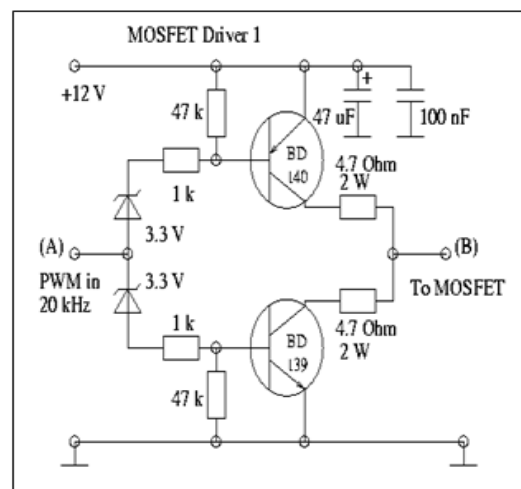


Figure 10. MOSFET gate driver

6. Application

- In industrial photovoltaic and fuel Cell
- Generation and energy storage Systems
- High-Intensity Discharge Lamp (Hid),
- Source with Dc Back-Up Energy Systems used for storage.
- Hybrid and Electric Vehicles.

7. Conclusion

This paper presents about novel design of resonant DC-DC converter with reduced supply voltage and increased current application for automotive purpose. The design methodology has the ability of getting high gain in voltage with less turns ratio in the transformer. By using interleaved step-up arrangement, the transformer will have less current stress. In addition, the transformer design is made easy because of low turns ratio. The efficiency of the converter is improved and the conduction loss is decreased by incorporating Zero voltage switching in the switching part and Zero Current Switching in the rectifier section. As a result, EMI issue is relieved there by making the circuit to work with high switching frequency. Therefore the control operation of the converter circuit becomes simple and the regulation of output voltage can be done by changing the duty ratio with respect to input voltage ranges. This model achieves high efficiency of about 95% with respect to input voltage and thus the model is more suitable for electric vehicles applications.

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