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Soft-Switching Design of Isolated Boost Converter with Coupled Inductor

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***Abstract*— In this paper the soft-switching design of isolated boost converter is analysed. the participation of resonance in the voltage doubler circuit, clamping capacitor and the reactance leakage in the coupled inductor. By choosing the proper magnetic inductance of the coupled inductors, soft-switching design (i.e) zero voltage switching is achieved to on the MOSFET without ay use of additional devices. The Duty cycle range is adjusted to achive Zero voltage switching and the optimal operation point is achivedwith the reduced current ripples, when duty cycle reaches 0.5.**

***Index Terms*—About four key words or phrases in alphabetical order, separated by com**

I. INTRODUCTION

In present Sineario, high voltage gain dc–dc boost converters play more and more imp role in many industry applications such as uninterrupted power supplies, electric traction,distributed photovoltaic (PV) generation systems, fuel cell energy conversion systems, automobile HID headlamps,and some medical equipments. THE conventional single-switch boost converter is widely employed in the distributed front-end power factor correction applications, such as the server power systems due to its advantages of simple structure, low cost, and easy implementation.At ideal continuous current mode (CCM) operation, the voltage gain of the conventional boost converter is only determined by the switch duty cycle, which means only one control freedom is available to regulate the output voltage. Therefore, its optimal voltage conversion ratio limited is to approximately four times with a relatively high efficiency.However, nearly or even over 10 times of voltage gain is expected in some high step-up applications.For example, the automobile high-intensity-discharge headlamps usually need to convert 12V onboard battery up to 100V at steady operation, even to 400V during the start-up stage. The 48V standard battery is required to be boosted to nearly 400V for back-up uninterruptable power systems. Furthermore, the output voltage of the individual photovoltaic (PV) cell is generally lower than 60V.However, the grid-connected ac voltage is 220V for single-phase local utility in most countries, which also calls for high step-up and high-efficiency converters to realize the integrated PV modules. In these high step-up and high output voltage applications, the extremely large duty cycle is inevitable with the conventional boost converter, which increases the switch peak current, deteriorates the switching condition, and expands the conduction and switching losses. In these high step-up and high output voltage applications, the extremely large duty cycle is inevitable with the conventional boost converter, which increases the switch peak current, deteriorates the switching condition, and expands the conduction and switching losses. Furthermore,from the small-signal model analysis, once the duty cycle is close to 1, the dynamic response of the boost converters is limited because there is only a small duty cycle regulation range during the transient operation. How to realize high step-up dc/dc converters without extreme duty cycle to improve the system performance is becoming one of the most emergent technologies for power electrics researchers.

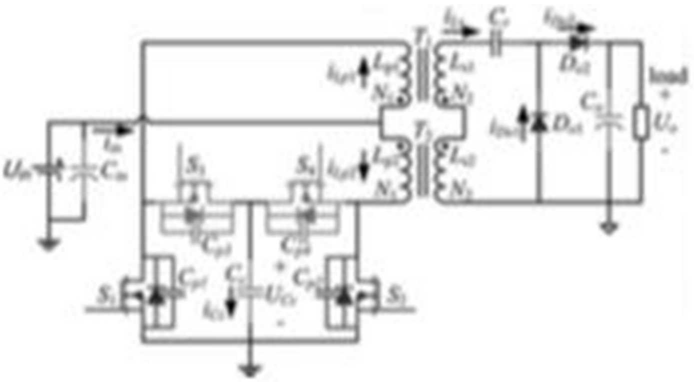
A **push–pull converter** is a type of DC-to-DC converter, a switching converter that uses a transformer to change the voltage of a DC power supply. The distinguishing feature of a push-pull converter is that the transformer primary is supplied with current from the input line by pairs of transistors in a symmetrical push-pull circuit. The transistors are alternately switched on and off, periodically reversing the current in the transformer. Therefore current is drawn from the line during both halves of the switching cycle. This contrasts with buck-boost converters, in which the input current is supplied by a single transistor which is switched on and off, so current is only drawn from the line during half the switching cycle. During the other half the output power is supplied by energy stored in inductors or capacitors in the power supply.

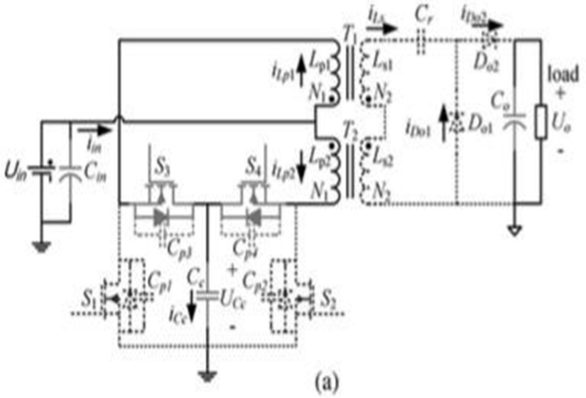
However, push–pull more commonly refers to a two-switch topology with a split primary winding.

In any case, the output is then rectified and sent to the load. Capacitors are often included at the output to filter the switching noise.

In practice, it is necessary to allow a small interval between powering the transformer one way and powering it the other: the “switches” are usually pairs of transistors (or similar devices), and were the two transistors in the pair to switch simultaneously there would be a risk of shorting out the power supply. Hence, a small wait is needed to avoid this problem. This wait time is called "Dead Time" and is necessary to avoid transistor shoot-through.

drawbacks of push-pull converter: High input current ripple because the current in the primary side is discontinuous, large transformer volume,leakage inductance which degrades power density, leakage inductance which degrades circuit performance.Reverse-recovery problem of secondary diodes is still remained and duty ratio must be larger than 0.5 to achieve ZVS on of the main MOSFETs.In this paper the soft-switching design of isolated boost converter is analysed,resonance analysis and soft-switching design of the isolated boost converter with coupled inductors are presented. Compared with the former proposed converter, both ZVS on of the main MOSFETs and zero-current switching (ZCS) off of the secondary diodes are obtained collectively at the same working conditions without any additional devices. Moreover, the range of duty ratio is enlarged due to the design and an optimal operation point is obtained when duty ratio approaches 0.5 and the ripple of input current moves in close to zero. The volume of the converter can also be decreased because of

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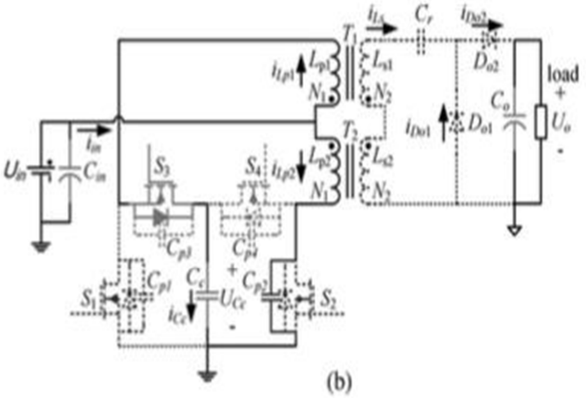
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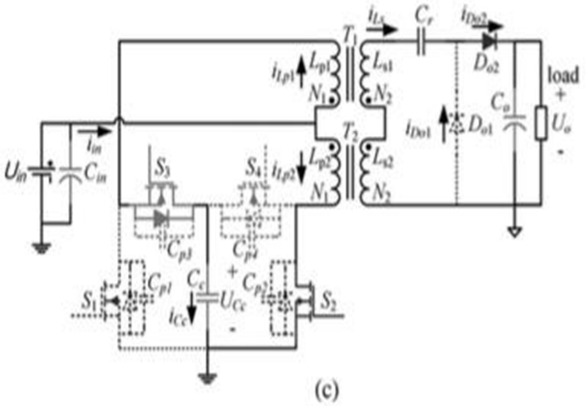
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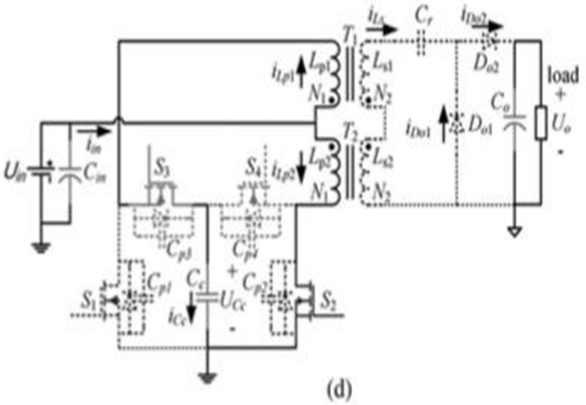

(d)

smaller transformers and smaller capacitors. A dc/dc converter for vehicle inverter is implemented to verify the design Be sure that the symbols in your equation have been

Design of the Optimized Resonance

In this particular vehicle inverter application, operation point at D = 0.5 is preferred because of minimized input current ripple. ZVS on of main switches can be achieved when magnetizing inductances are small enough. Meanwhile, ZCS off of secondary diodes is designed within the whole input voltage and load range. Due to relatively high turn ratio of transformer, Cc needs to be extraordinarily large to obtain secondary-dominant resonance. In the designed converter, a communal clamping capacitor Cc is used and its capacitance is properly not large due to the design of optimized resonance. Thus, the designed resonance is between the aforementioned two resonances and the volume of capacitor is reduced. Three factors should be considered for design of this optimized resonance.

Duration of resonance. In order to achieve ZCS off of secondary diodes, duration of resonance should be shorter than minimal overlapping interval (D >0.5) or nonoverlapping interval (D <0.5). However when duration of resonance is shortened, the peak of resonant current rises to transfer equivalent energy. That means Cc and Cr should be sufficiently large to alleviate current stress of both primary and secondary side.

Ripple of clamping voltage. Main MOSFETs will sustain high voltage stress if Cc is too small. Hence, Cc should restrict the ripple of clamping voltage into an acceptable range.

Capacitor volume. After taking the previous two into consideration, a combination of Cc and Cr should be adopted to get minimal volume of capacitors.

In this converter, Cr is 47 nF and Cc is 3 μF while turn ratio of transformer is 3:3:24. Obviously, the resonance is the one between primary-dominant resonance and secondary-dominant resonance.

Mode of operation -Operational Principle for D<0.5

When D is small than 0.5, resonance operates at non-overlapping interval

Mode 1 [t0,t1]

S1 is turned OFF at t0 while S2 is off, Inductor Lp1 and Lp2 are discharging and di/dt equals (Uin–UCc) /Lp, Due to small inductance of Lp1 and Lp2, iLp2 is under zero at t1,

The reverse current is flowing from clamping capacitor Cc, auxiliary MOSFET S4 to inductor Lp2,No energy is transferred to secondary side.

Mode 2[t1,t2]

S4 is turned OFF at t1 when iLp2 is reverse, Inductor Lp2 discharges parasitic capacitor Cp2 of S2 for free-wheeling, If the reverse current of Lp2 is large enough, there will be sufficient energy to discharge uDS2 to zero at t2.

Mode 3 [t2,t3]

S2is turned ON at t2 when uDS2 reaches zero. ZVS on of S2 is achieved. S1 is still off. Hence, inductor Lp1 is discharging and di/dt equals(Uin–Ucc)/Lp, Inductor Lp2 is charging and di/dt equals Uin/Lp., Secondary circuit begins to conduct. Transformer T1 works as a flyback converter and transformer T2 works as a forward converter, Leakage inductor of transformer, clamping capacitor Cc and voltage doubler capacitor Cr start to resonate, Therefore, both iLp1 and iLp2 contain magnetizing current and resonant current.

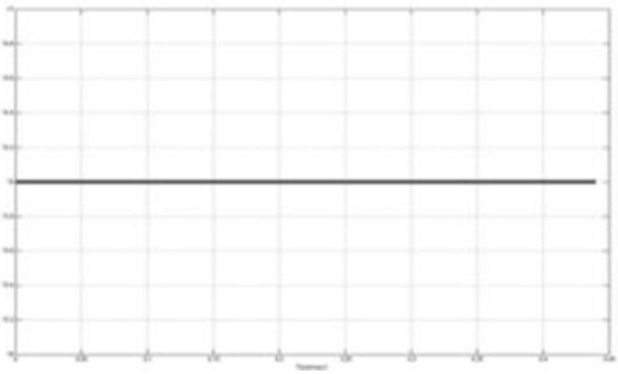
Mode 4[t3,t4]

Secondary current iLs decreases to zero at t3 and resonant circuit is cut off by diode Do2, Therefore, secondary diode is turned OFF softly and reverse recovery problem is removed, Inductor Lp1 is still discharging with rate determined by (Uin–Ucc)/Lp, Inductor Lp2 is still charging with rate determined by Uin/Lp.

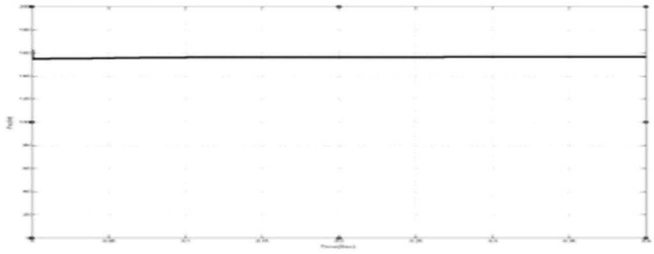
II. SIMULATION OUTPUT RESULT

INPUT VOLTAGE:

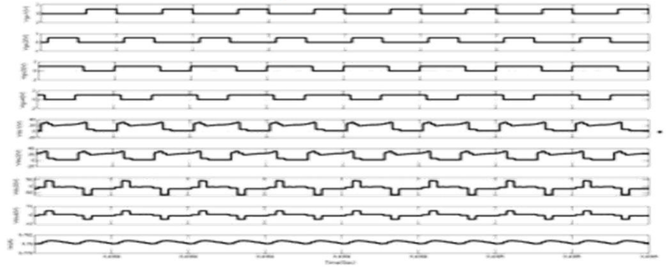
!2



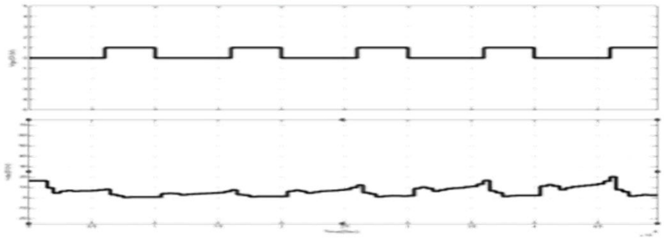
INPUT POWER:



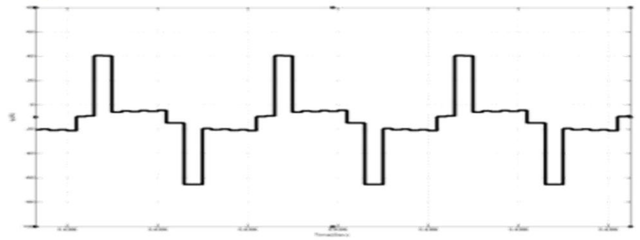
Gate Pulse with Drain source voltage of all Switch



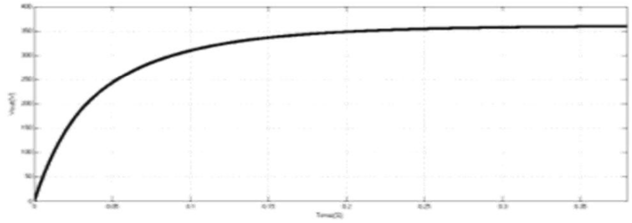
Gate Pulse with Drain source voltage of S1



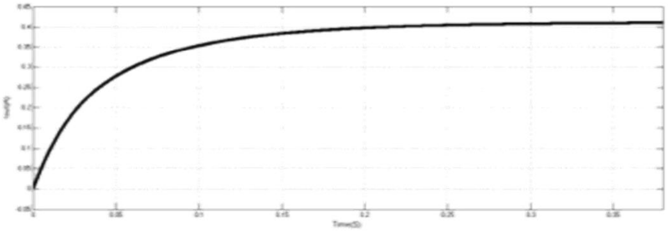
Primary Current



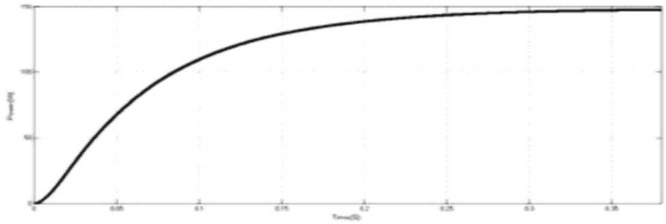
Output voltage



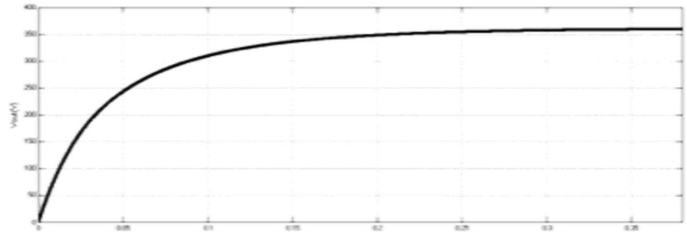
Output current



Output power



Output voltage



Simulation Experimental Result

The above fig shows the Comparison of Gate Pulse with Drain source voltage of S

IV. CONCLUSION

In this project, resonance analysis and soft-switching design of an isolated boost converter with coupled inductors are presented.The choosing appropriate magnetic inductance of the coupled inductors, ZVS on of the main MOSFETs and ZCS off of the secondary diodes can be achieved collectively at the same working conditions without any additional devices. At last, a 150 W, 12–360 V high efficiency prototype converter is built to verify the analysis, and the experimental results illustrate that the proposed converter is a competitive candidate for low power and high step-up applications with isolation requirements.

V. ACKNOWLEDGMENT

The preferred spelling of the word “acknowledgment” in American English is without an “e” after the “g.” Use the singular heading even if you have many acknowledgments. Avoid expressions such as “One of us (S.B.A.) would like to thank ... .” Instead, write “F. A. Author thanks ... .” **Sponsor and financial support acknowledgments are placed in the unnumbered footnote on the first page**.

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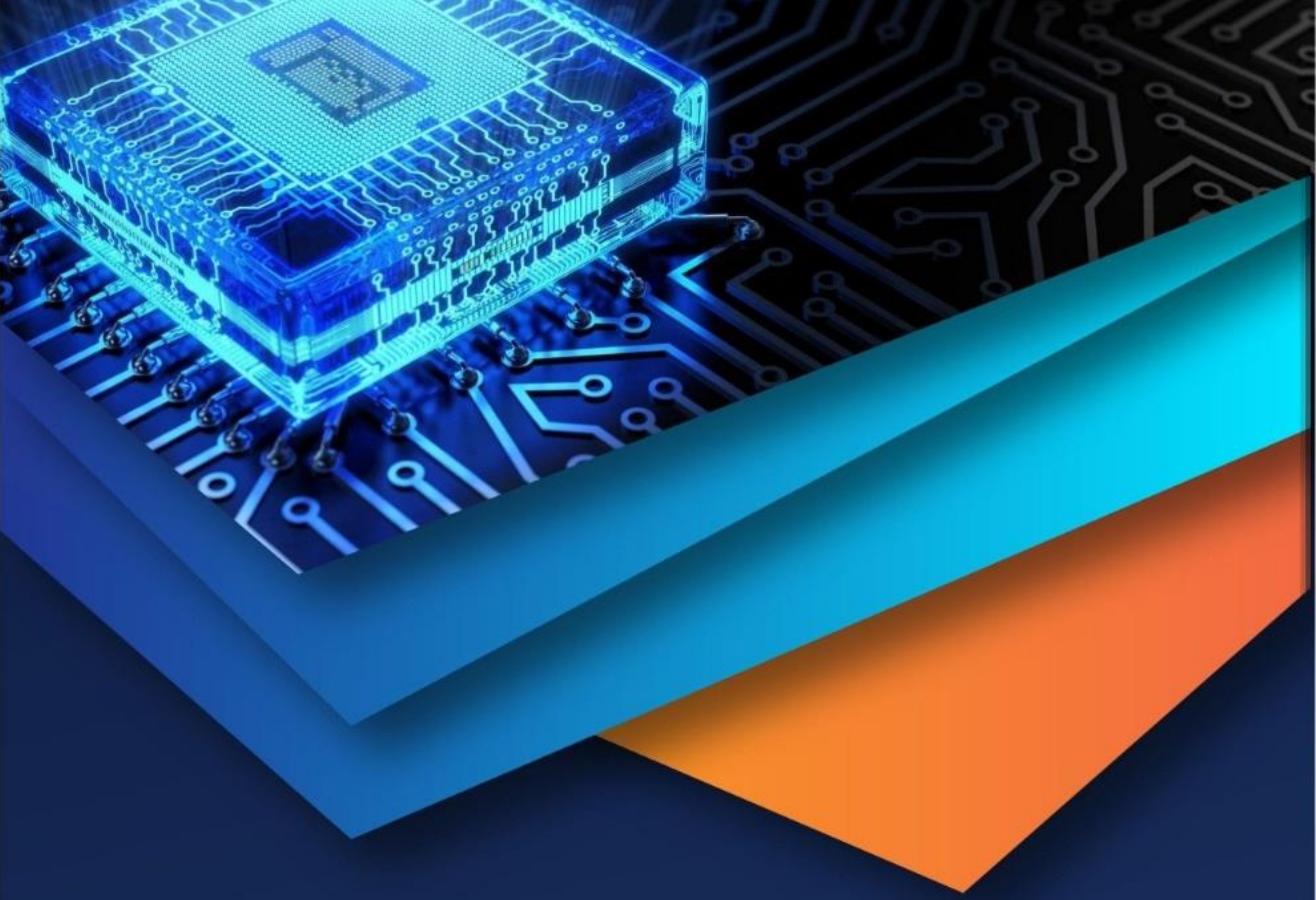

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