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A BIDIRECTIONAL SWITCH BASED HIGH-EFFICIENCY ISOLATED RESONANT CONVERTER FOR PLUG-IN HYBRID ELECTRIC VEHICLE CHARGING APPLICATION

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Abstract: This paper presents a high efficiency resonant converter over a wide output voltage range with PV module for PHEV application. This method brings voltage regulation by using technique of fixed frequency pulse width modulation(PWM) control, by adding bidirectional switch on secondary side of resonant converter and direct power transfer to load is also achieved ref [1][2]. Simulation results are given to confirm the proposed method achieves wide range of voltage. Thus the proposed method provides high efficiency and it is more suited for battery charging application, PLUG-IN hybrid electric vehicle (PHEV) ref[6].Experimental results shows that the proposed method of hybrid series resonant and PWM boost converter can achieve the peak efficiency of over wide range.

KEYWORD: Full bridge inverter, hybrid series resonant converter, PWM boost converter, bidirectional switches.

INTRODUCTION

One of the fastest growing resources in the renewable energy is PHOTOVOLTAIC (PV) energy. So in order to continue its growth in future use both panel and power conditioning system of PV has designed to efficiently perform. Among all renewable energy sources, PHOTOVOLTAIC (PV) sources have no limitation of supply and predicted to become biggest contributors to electricity generation among all renewable resources.

A new hybrid series resonant converter and PWM boost converter is proposed in this paper. Though there are other types of isolated DC-DC converter available like fly back and its variants active-clamp fly back and quasi resonant boundary conduction mode fly back, it has inability to perform high efficiency and does not provide power transfer from source to load ref [1].

Other efficient one is series resonant converter, used mostly for high voltage. It achieves zero voltage switching (ZVS) and zero current switching (ZCS) but problem is lack of input voltage regulation which is more important for PV application.LLC converter is also an isolated DC-DC converter but it has problem to achieve wide range application ref [2]. By using resonant converter it can be able to get wide load range and there is no increment in current stress with wide input range.

These drawbacks can be overcome by using this new hybrid series resonant and PWM boost converter which provide direct power transfer to load and it also achieves zero voltage switching (ZVS) and zero current switching (ZCS) of output diodes and through fixed frequency PWM control by using bidirectional switch it is able to provide voltage regulation.

By using fixed frequency PWM method used to control switches S1-S4 in order to provide ZVS like full bridge inverter. Thus this method provides low circulating current along with advantage of ZVS and on secondary side ZCS is achieved. Combines advantage of both series resonant and LLC converter ref [3]. By using the bidirectional ac switch provides regulation capability makes the converter to operate always at series resonant frequency.

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TOPOLOGY OF PROPOSED RESONANT CONVERTER:

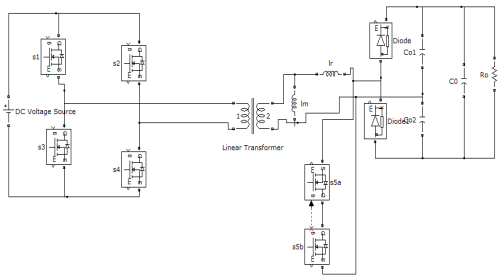

Fig 1 proposed model circuit diagram

CONVERTER OPERATION:

A)TOPOLOGY:

The proposed method consist of full bridge inverter and the design exactly looks like series resonant converter except with addition of bidirectional switch at the secondary side of transformer. In order to reduce the switch count the method can also be implement with half bridge and push-pull converter.The bidirectional switch which is connected in secondary side formed by connecting drains of two mosfet ref [1].The primary side circuit consist of a full bridge inverter rather than driving the switches simultaneously, the lower switches S3 and S4 are driven at a fixed 50% duty cycle and the upper switch S1 and S2 are PWM on the trailing edge(Fig 2).In continuous conduction mode(CCM) for all switches ZVS is achieved with RMS currents low, high di/dt with large reverse losses results in high voltage ringing. It also requires larger resonant inductor leads to turns ratio of transformer to increase and more stress on primary side. By using this trailing edge method discontinuous conduction mode(DCM) switching losses will be less and low di/dt range obtained with minimized reverse recovery losses ref [6].

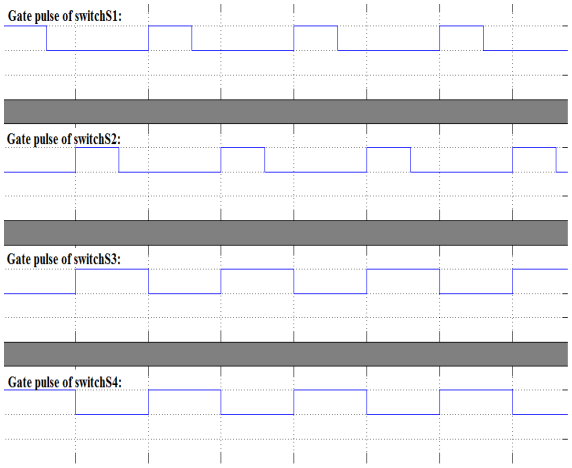

Fig 2 Gate pulses for Full bridge converter switches S1,S2,S3,S4.

B)MODES OF OPERATION:

1)MODE1 (t0 to t1)[see Fig 3a]:

During this mode,there will be positive flow of current in the primary side of the isolated transformer.

when switches S1 and S4 turned ON and bidirectional switch S5 on secondary side of transformer will be turned ON, now it works like boost converter. Lr acts as boost inductor.voltage across the capacitor bank will be constant in this mode.

2) MODE 2(t1 to t2)[see Fig3b]:

This mode starts when switch S5 switched OFF,now it works like series resonant coonverter. Capacitor banks used Cr1 and Cr2 starts to resonant.

3) MODE 3(t2 to t3)[see Fig 3c]:

In this mode no power is transferred. It maintain frequency to constant and ZCS is achieved across the diode.

4) MODE 4(t3 to t4)[see Fig 3d]:

Here switches S4 and S4 are turned OFF. In this period magnetising inductance Lm is at maximum.

5) MODE 5(t4 to t5)[see Fig 3e]:

Switches S2 and S5 are turned ON and there will be negative flow of voltage across primary side. S5 also turns ON. Again the converter operates like BOOST mode.

6) MODE 6(t5 to t6)[see Fig 3f]:

The bididirectional ac switch S5 switched OFF in this mode,now again the converter looks like working in series resonant mode.

7) MODE 7(t6 to t7)[see Fig 3g]:

There is no transfer of power from load to source in this mode. Idle mode is achieved in this period.

8) MODE 8(t7 to t0)[see Fig 3h]:

Now switches of S2,S3 are switched OFF. Lr leakage inductance is at low. This current makes the capacitors of S1,S4 to discharge and capacitors of S2,S3 to charge.

C)MODES OF OPERATIONS DIAGRAM:

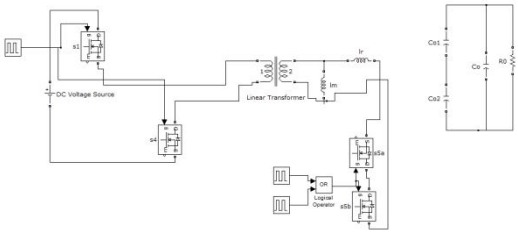

Fig 3a.

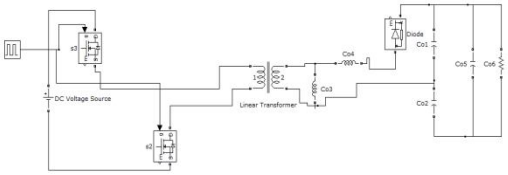

Fig 3b.

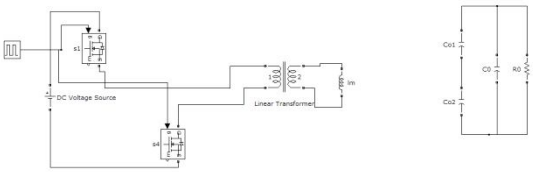

Fig 3c.

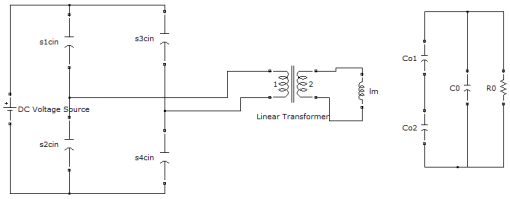

Fig 3d.

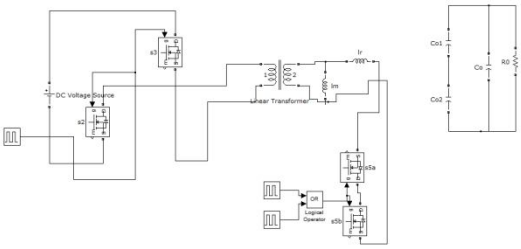

Fig 3e.

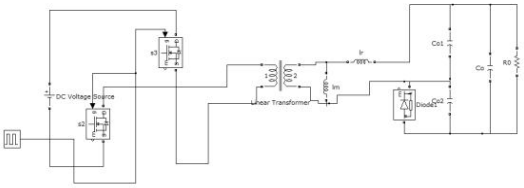

Fig 3f.

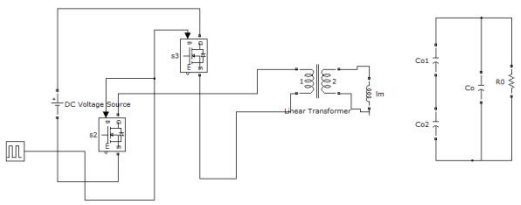

Fig3g.

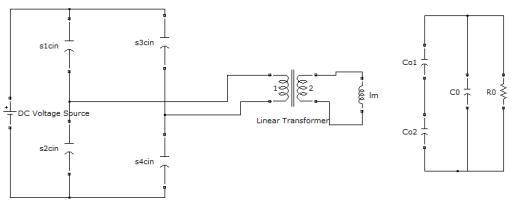

Fig 3h.

Fig 3 Modes of operation.

GATE WAVEFORM:

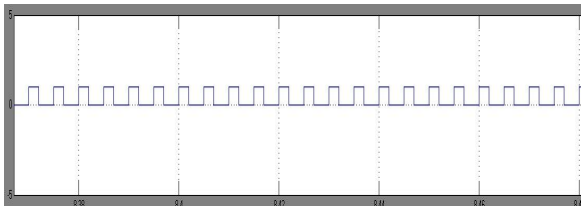

Fig 4. Gate pulse of switches.

The duty cycle of ac switch used S5a and S5b [see Fig 4]should be small for most of the operation so that there will be transfer of power directly from source to load will occur and it should be turned ON continously with simultaneous switching of full bridge converter switches.

EXPERIMENTAL RESULT

300 watts output power can be developed by using this proposed method with the input voltage of 30V. In order to operate the converter under normal ac switch operation,the transformer turns ratio was selected. The ac switch used to control voltage regulation.

A.INPUT VOLTAGE AND TRANSFORMER OUTPUT WAVEFORM:

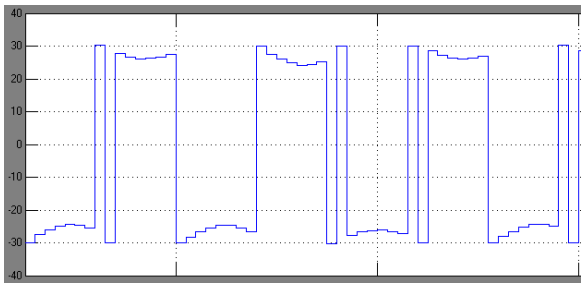

Fig 5 input votage of 30V.

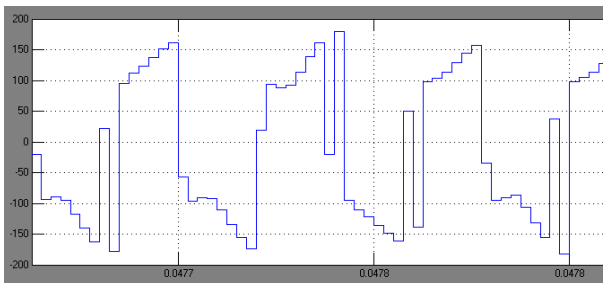

Fig 6 Transformer output.

B.OUTPUT VOLTAGE AND CURRENT WAVEFORM

By the use of this proposed new series resonant converter and PWM boost converter 300V output voltage[Fig 7a] can be achieved with input voltage of 30V and with output current of 0.85A[Fig 7b].

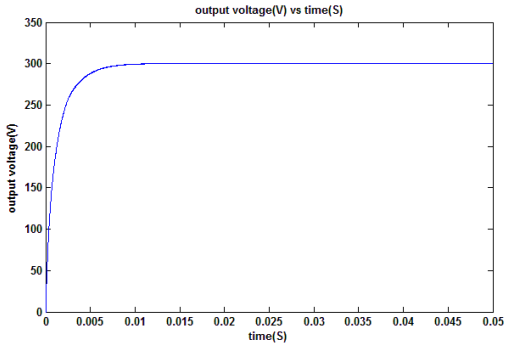

Fig 7a output voltage of 300V.

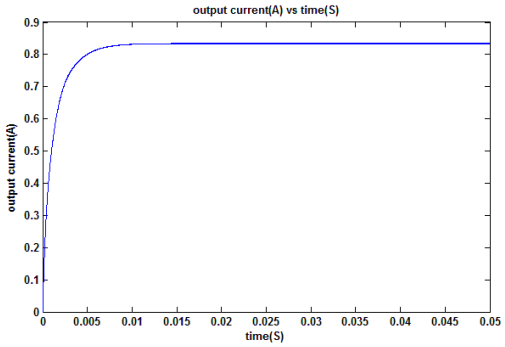

Fig 7b output current of 0.85A.

CONCLUSION

This method of hybrid series resonant and PWM boost converter, a wide range of voltage can be achieved for application of PHEV. At primary side ZVS is achieved with low current switching and on the secondary side ZCS of output diode. The proposed method brings transfer of direct power to load side and with using bidirectional switch, fixed frequency PWM control voltage regulation also be achieved.

PHEV specification	Proposed method results
voltage-300V Current-0.7A	Voltage-300.2V Current-0.8A

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