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Research Paper

A SIMPLE AC-DC CONVERTER WITH INDIRECT FEEDBACK

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A simple low power low voltage AC-DC converter with indirect feedback is presented in this paper. Low power driver circuits can be benefited; since it converts low AC voltage (millivoltage range) to high DC voltage (3.3 volt DC). Direct AC to DC conversion reduces the complexity of the system. The control and driver circuits play a key role in proposed system as the whole system is low voltage/power based. The lack of common ground has implementation difficulty both in feedback and control. Indirect feedback is used to avoid such conditions. The system is more efficient and compact. The feedback section is very simple and thus easy to implement, which also consume low power. An auxiliary supply is also designed to provide power to the gate drivers. For varying load the indirect feedback can be utilized. The design and selection of critical components are discussed. Using MATLAB/Simulink the proposed AC-DC converter is simulated and outputs are obtained.

Keywords: AC-DC converter, Indirect feedback, MOSFET, Auxiliary supply, MATLAB/Simulink, Low power, Low voltage

INTRODUCTION

The recent development of compact and efficient semiconductor technologies provide a breakthrough in the low power applications [1]. Such applications include converter system with very sensitive control scheme. The current trend is of 'self powered' system, which can avoid the replacement of batteries as the energy source. Such self powered system can be used in the low power wireless applications.

One among the low power energy harvesting system is the electromagnetic microgenerators [3, 4]. These device utilise the vibration due to any cause which can be of reasonable (according to the specification of microgenerator) frequency range. They are efficient method to convert vibration into electrical energy. In case of such devices also AC-DC converter with low power and voltage can be utilised as a perfect power processing interface.Numerous AC-DC converters have

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been reported which can boost low voltage AC to higher (2-3.3 V) steady DC.

Dual polarity boost converter [5] was a presented type, but has less efficiency in simulation results itself. Another presented topology involved with p-channel and n-channel MOSFET [6]. The drawbacks of such converter designs can be overcome using implementation of bidirectional switches [2]. There are two types of topologies can be implemented in the converter type which is being discussed in this paper.

- Secondary side diode topology
- Split capacitor topology

The secondary side diode topology has diodes where they are the rectifying path for the inductor current. The stresses in the diodes are more in such topology which are also considered in an efficient system, especially when it comes to the system with low ratings. Another topology is the split capacitor [2] where two capacitors provide output voltage. This reduces the stress in the components, since voltage through each split capacitor is half of the average output of the system.

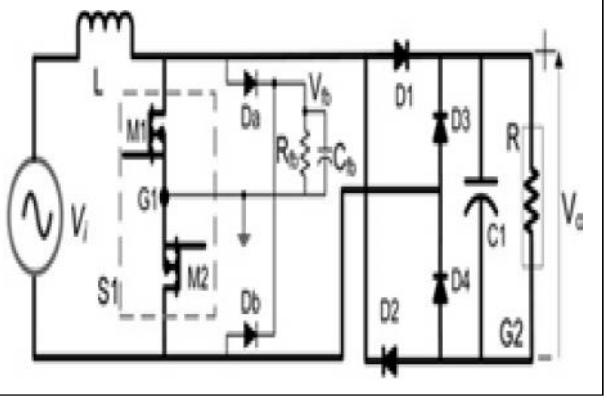
A simple indirect feedback is utilised in the closed loop control. In Figure 2, the feedback voltage V_{fc} is taken with ground G_1 as the reference. While for the output, node G_2 is taken as the reference. This circuit can be used to emulate load impedance with a circuit, which is referenced to ground G_1 instead of node G_2.

An auxiliary circuit can be used to power the gate driver and control circuits. The proposed setup is to work for both split capacitor topology and secondary side diode topology. The topologies are simulated using MATLAB/Simulink simulation software and results shows satisfactory performance.

CIRCUIT OF NEW PROPOSED TOPOLOGY

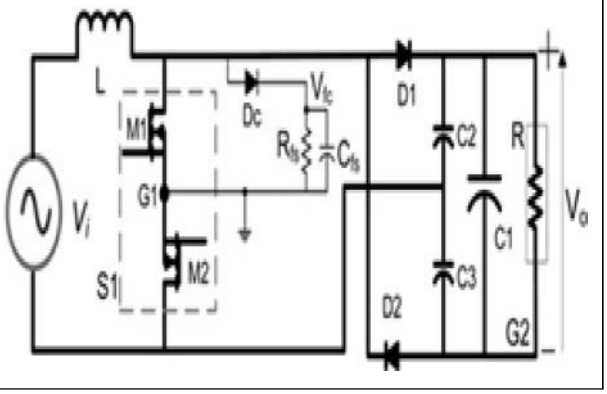
Figure 1 shows a secondary side diode topology. The converter design has a single inductor L in both the input half cycles for the boost operation. In the bidirectional switch S_1 both MOSFETs turn on and off at same time. When switch is on inductor L is charging and while S_1 is off the inductor energy is transferred to output capacitor(s).

Figure 1: Secondary Side Diode Topology



The charging/discharging of inductor is when switch is on/off is similiar in the case of split capacitor topology shows in Figure 2.

Figure 2: Split Capacitor Topology



OPERATION OF NEW PROPOSED TOPOLOGY

The working of both topologies can be described using four modes. In diode based topology, during positive half cycle diodes D_1 and D_4 conducts. In same way during negative cycle diodes D_2 and D_3 conducts. The capacitor C_1 is continuously charged in both half cycle in the same direction.

For split capacitor topology, capacitor C_2 is charged through diode D_1 in positive cycle, whereas capacitor C_3 is charged in negative cycle through D_2. The output capacitor C_1 is maintained in constant voltage.

Figure 3: Modes of Operation of He Proposed System (Mode I, II and III)

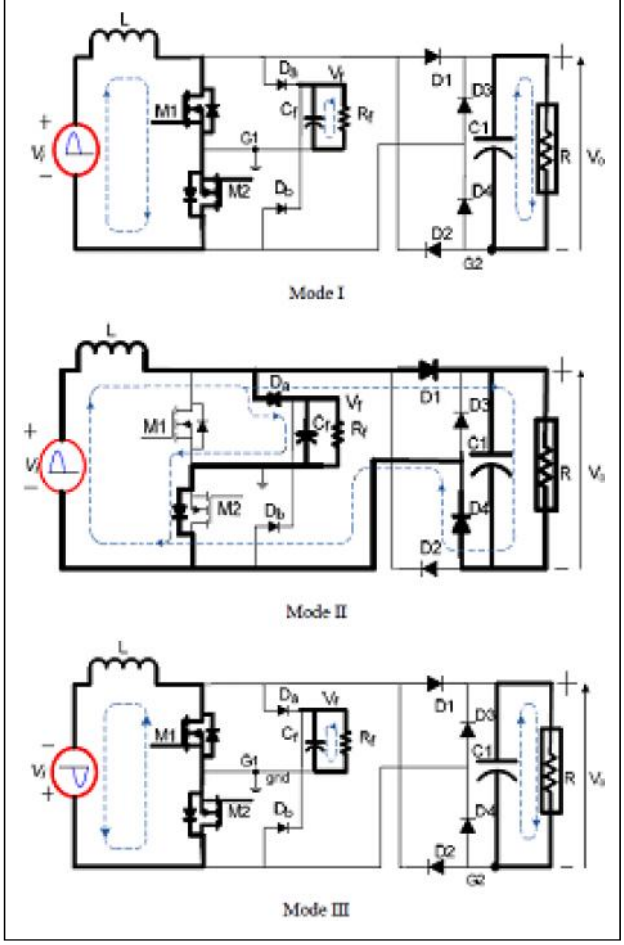
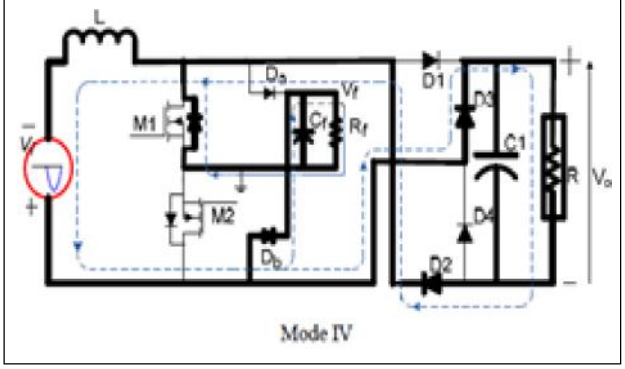


Figure 4: Mode IV of the Proposed System



Mode 1

The switch S_1 is turn on in positive half cycle. The inductor current rises from zero. Also in this mode capacitor C_1 is discharging through R and capacitor C_f through R_f.

Mode 2

When the switch S_1 is off in the positive half cycle, the inductor current charges both capacitors C_1 and C_f are charged. C_1 through the diodes D_1 and D_4, whereas C_f by D_a and BD_{M2}. Here BD_{M2} is the body diode of the MOSFET M_2. In split capacitor topology during this mode capacitor C_2 is charged through D_1.

Mode 3

This mode is when the switch S_1 is on in negative half cycle. The inductor current rise from zero but the current is negative. The diode based topology work similar to the mode 1 where the output capacitor charges in the same direction. Similiarly in split capacitor topology the negative inductor current charges the split capacitors.

MODE 4

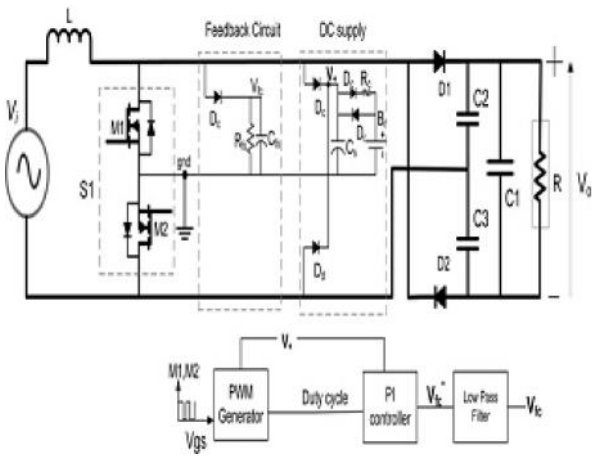
In this mode the switch is off in negative cycle. The inductor current is negative and in this mode, the inductor energy is transferred to the output side.

CLOSED LOOP OPERATION

The indirect feedback is a simple circuit consist of a capacitor and a resistor. The feedback voltage is given to PI controller and then it is given to PWM generator. The PWM generator provides the corrected pulse signals to the gate of the MOSFETs.

Auxiliary supply circuit is also provided in the system which will power both the control and driver circuit.

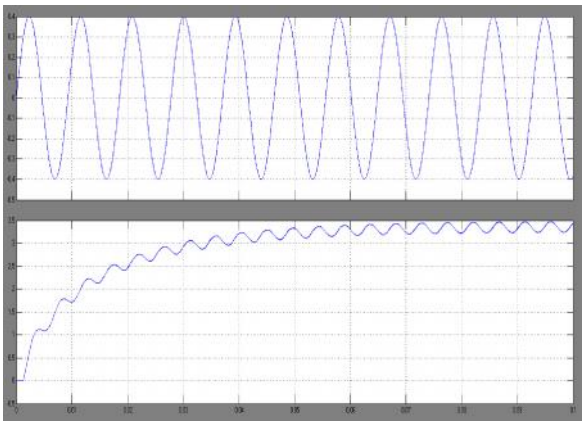
Figure 5: Converter Circuit



SIMULATION RESULTS

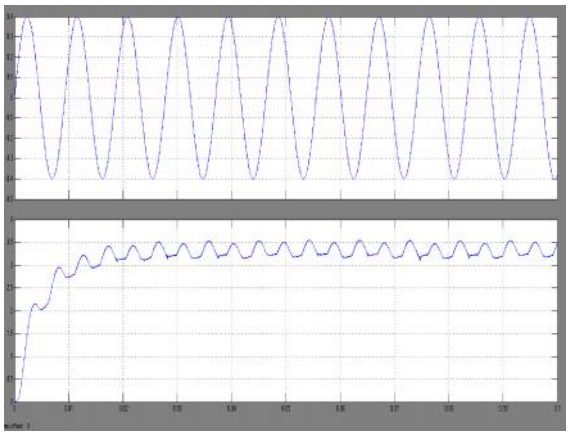
The simulation is done using Matlab/Simulink,

Figure 5: Simulation Output for Diode Based Circuit



which is a computer-aided simulation tool to verify the validity of the circuit. The circuit is simulated with an input AC voltage of 400mV. The duty cycle of 50% and other components are obtained according to the design. Figure 5 shows the simulation output window obtained from the Matlab. From the figure, the voltage and current of the converter closed loop system can be noted.

Figure 6: Simulation Output for Split Capacitor Circuit



CONCLUSION

The proposed topology has more efficiency comparing to the existing or early proposed designs. The system has novel indirect feedback which is easy to implement. An auxiliary supply is provided to the system for powering the control and driver circuit. The split capacitor topology simulation output is more efficient than the diode based, since there are stresses in the diodes present.

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