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A SINGLE-SWITCH RESONANT POWER CONVERTER FOR SOLAR PV SYSTEM

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Abstract- Topology integrates a single-switch resonant inverter with zero-voltage-switching (ZVS) with an energy blocking diode with zero-current-switching (ZCS). The energy blocking diode with a direct current (DC) output filter filters the output stage of the single-switch resonant inverter. Only one active power switch is used for power energy conversion to reduce the cost of active power switches and control circuits. The active power switch is controlled by pulse-width-modulation (PWM) at a variable switching frequency and constant duty cycle. When the resonant converter is operated at discontinuous conduction mode (DCM), the inductor current through the resonant tank could achieve ZCS of the energy-blocking diode. Accordingly, high energy conversion efficiency is ensured.

Keywords – Pulse Width Modulation (PWM), Zero-Voltage-Switching (ZVS), Zero-Current Switching (ZCS), Photo Voltaic (PV), Discontinuous Conduction Mode (DCM)

I. INTRODUCTION

Rising prices for traditional fossil fuel sources, coupled with rapidly falling prices for poly-crystalline silicon panels, has resulted in an increased acceptance rate for PV systems. The voltage obtained is less, so it has to be boosted up to a high value for various applications. Here Integrated Boost converter with closed loop control is focused.

A typical DC-DC converter is encompasses of active switches such as MOSFETs or IGBTs, diodes, magnetic components for example inductors and transformers, and static devices like capacitors. Magnetic components are heavier and needs more volume than any other parts in a power electronic converter. The size of the magnetic components is conversely proportional to the switching frequency of the DC-DC converter. In order to decrease the volume and weight of converter, higher switching frequency must be chosen [1] .

The voltage across or current through the semiconductor switch is abruptly altered; this approach is called hard-switching PWM. Because of its simplicity, relatively low current stress, and ease of control, hard-switching PWM approaches have been preferred in modern power electronics converters. Owing to the rapid developments of new power device technologies, the switching speed of power devices has increased greatly. Therefore, PWM power converters can now operate at a much higher switching frequency, reducing the size of passive components, reducing the overall cost of the system. This paper proposes a single switch resonant converter is to construct a high-efficiency power electronic converter that can be implemented in the renewable energy generation systems, decrease High voltage and current stress problems.

By solving these high voltage and current stress problems, energy conversions using resonant converters has been important in ensuring both high performance and supporting energy conservation applications in renewable energy generation systems. The switching loss increases with the switching frequency, reducing the efficiency of the resonant converters. To solve this problem, some soft switching approaches must be used at high switching frequencies. Zero-Voltage-Switched (ZVS) technique and Zero-Current Switched (ZCS) technique are two commonly used soft switching methods. The proposed converter maintains ZVS for the universal input voltage, which includes a very wide range of duty ratios. In addition, the control system optimizes the amount of reactive current required to guarantee ZVS during the line cycle for different load conditions. This optimization is crucial in this application since the converter may work at very light loads for a long period of time.

A. Boost Converter

The boost is an acknowledged non-isolated power stage topology, sometimes called a step-up power stage. Power supply designers desire the boost power stage because the needed output is always more than the input voltage. The input current for a boost power stage is unremitting, or non-pulsating, because the output diode conducts simply during a segment of the switching cycle. The output capacitor provides the entire load current for the remaining of the switching cycle.

A power stage can work in continuous or discontinuous inductor current mode. In continuous inductor current mode, current flows continuously in the inductor during the whole switching cycle in steady-state operation [3]. In discontinuous inductor current mode, inductor current is zero for a segment of the switching cycle. It begins at zero, achieves peak value, and return to zero through each switching cycle. It is advantageous for a power stage to stay in only one mode over its expected operating conditions because the power stage frequency response alters significantly between the two modes of operation.

II. OPERATION OF THE PROPOSED SYSTEM

A. Block Diagram

The input from solar panel is given to resonant converter which feds the load is the main circuit of the system as shown in fig.2.1 Resonant power converters contain resonant L-C networks whose voltage and current waveforms vary sinusoidal during one or more subintervals of each switching period. These sinusoidal variations are large in magnitude, and the small ripple approximation does not apply. Turn-on or turn-off transitions of semiconductor devices can occur at zero crossings of current waveforms, thereby reducing the switching losses. Hence resonant converters can operate at higher switching frequencies than comparable PWM converters.

The driver circuit is of low voltage and low power. The power circuit consisting of switches is a high voltage and high power circuit. Thus it is necessary for gate pulse generating circuit to be isolated from one another and from the power circuit. The primary function of a drive circuit is to switch a power semiconductor device from off state to on and vice versa. Separate isolated power supplies are required for each power device in the converter. There are two types of isolators:-the pulse transformers and optical isolators

The controller unit has been designed for giving proper gate voltages to the switches. PIC microcontroller can be used as the controller.

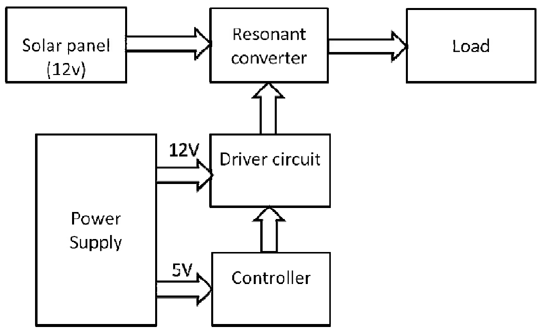

Fig. 2.1 Block Diagram of proposed System

B. *Circuit Topology*

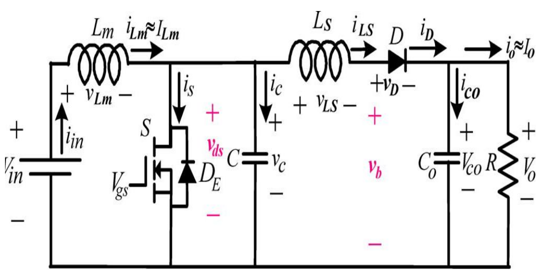

Fig. 2.2 Circuit Topology of proposed System

In the proposed system, a high-efficiency power electronic converter that can be implemented in the renewable energy generation systems. The soft switching has potential to provide lossless switching and has become increasingly popular with researchers. This work develops a current-fed resonant converter with ZVS and ZCS operations of both the active power switch and the rectifying diode for energy conversion. It comprises a choke inductor L_m, a MOSFET that operates as a power switch S, a shunt capacitor C, a resonant inductor Ls, an energy-blocking diode D, and a filter capacitor C_o. The capacitor Co and the load resistance R together form a first-order low-pass output filter, which reduces the ripple voltage below a specified level. The MOSFET is a favored device because its body diode can be used as an anti-parallel diode DE for a bidirectional power switch. Notably, the shunt capacitance C includes the power switch parasitic capacitance and any other stray capacitances. Careful design of the circuit parameters guarantees that the power switch S is switched by ZVS and the energy-blocking diode D is switched by ZCS, optimizing the operation of the converter.

Mode 1

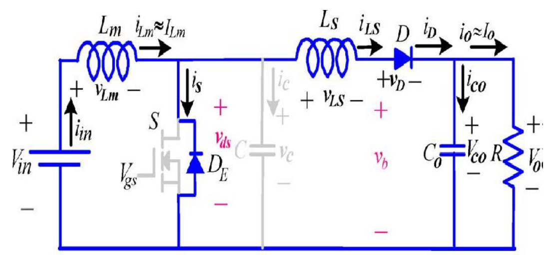

Figure 2.3 Circuit for Mode 1 Operation

Initially switch S is turned off. The resonant tank circuit current I_{Ls} is positive and exceeds the DC input current I_{lm}. The power switch must be turned on only at zero voltage and the energy stored in the capacitor C.

The anti-parallel diode D_E must conduct before the power switch is turned on. When the capacitor voltage v_C falls to zero, a turn-on signal is applied to the gate of the active power switch S.

( ) = − —(−) + [1]

( ) = 0 [2]

Mode 2

The switch S remains in the ON state. The line voltage is applied to the choke inductor Lm, and i_{Lm} increases continuously.

In this mode, the current i_L-i_{Ls} naturally commutates from the anti parallel diode DE to the active power switch S. The voltage across the capacitor C is clamped at zero. The resonant current i_{Ls} passes through the energy-blocking diode D. This mode end as the inductor current i_{Ls} falls to zero.

( ) = − —(−) + [3]

( ) = − —(−) + [4]

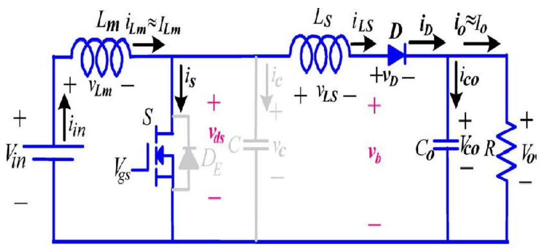

Figure 2.4 Circuit for Mode 2 Operation

Mode 3

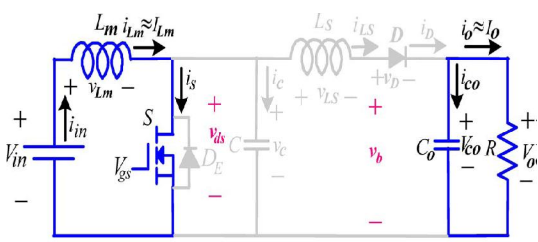

Figure 2.3 Circuit for Mode 3 Operation

After The switch S remains in the on state and the input DC current i_{Lm} continuously increases. The inductor current i_{Ls} falls until it reaches zero and is prevented from going negative by the energy-blocking diode D .The DC input source is never connected directly to the output load in the single-switch converter.

Energy is stored in the Lm when the active power switch is turned on and is transferred to the output load when the switch is turned off the mode is excited at the time when the power switch S is turned off.

( ) = 0 [5]

( ) = 0 [6]

Mode 4

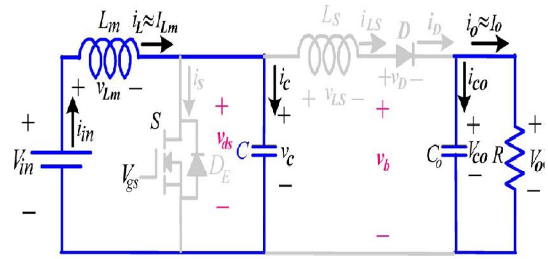

Figure 2.4 Circuit for Mode 4 Operation

The switch S is turned off. For ZVS operation, S is switched off at zero voltage, and the capacitor voltage v_c increases linearly from zero at a rate that is proportional to i_{Lm}. The capacitor current i_c flows through capacitor C to charge C, transferring the energy from the DC input source to capacitor C.

During this mode, the output power of load resistor R is supplied by the output capacitor C_o. This mode ends when the energy-blocking diode D is forward biased.

( ) = —(−) [7]

Mode 5

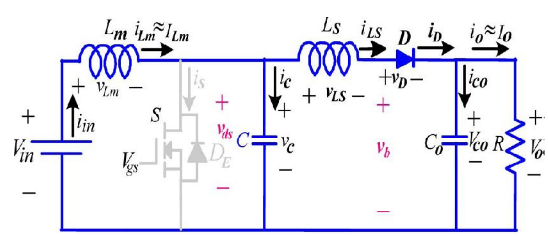

Figure 2.5 Circuit for Mode 2 Operation

The switch S remains in the off state. The inductor current i_{Ls} is positive and the energy blocking diodes D is turned on the capacitor current i_C is still positive: This Mode ends when capacitor current i_C resonates to zero at ωt5.

( ) = —(−) [8]

Mode 6

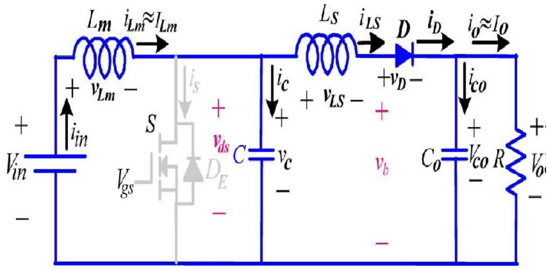

Figure 2.6 Circuit for Mode 2 Operation

When capacitor voltage v_c resonates from negative values to zero. The active power switch S is turned on when $\omega t = 2\pi$ to eliminate switching losses

In addition to the active power switch, the energy-blocking diode in the converter is also commutated under soft switching.

III. SIMULATION

A. Simulation Circuit

The figure below shows the simulation circuit of the entire project showing solar panel connected as the input to the single-switch resonant power converter. The pulse to the switch is generated through MATLAB program.

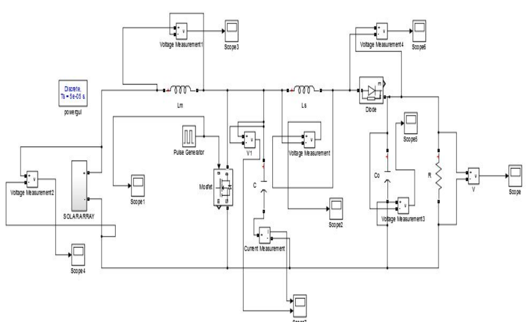

Figure 3.1 Complete Simulation Circuit

B.Simulation Results

The various simulation results are given below.

The simulation result for input voltage from the solar panel is shown in Fig 3.3.

The simulation result for inductor l1 is shown in Fig 3.4 and inductor l2 is shown in Fig.3.5

The voltage waveform of capacitor C is shown in Fig.3.6.

The pulses generated using MATLAB program for the switcheS1 is shown in Fig.3.7.

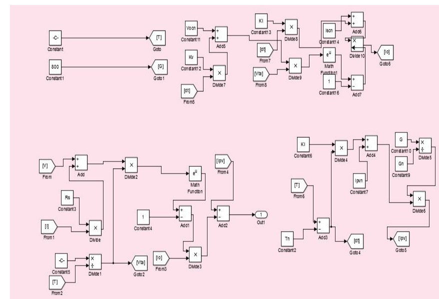

Figure.3.2 subsystem of Solar Panel.

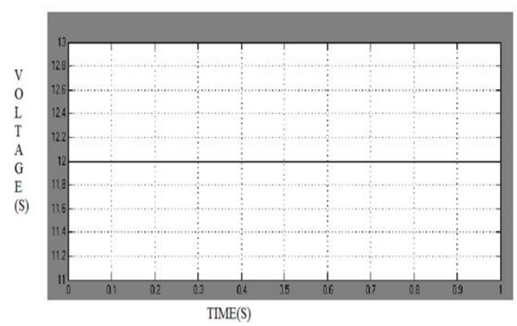

Figure.3.3 Input Voltage from Solar Panel**.**

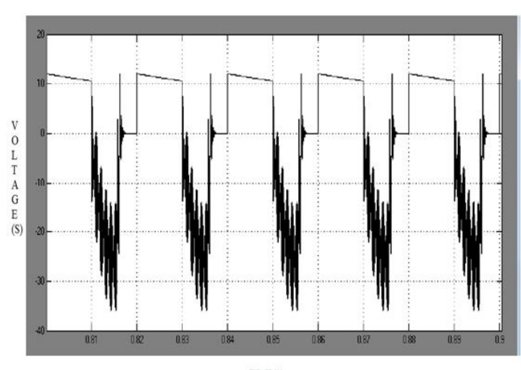

Figure.3.4 voltage waveform of inductor l1

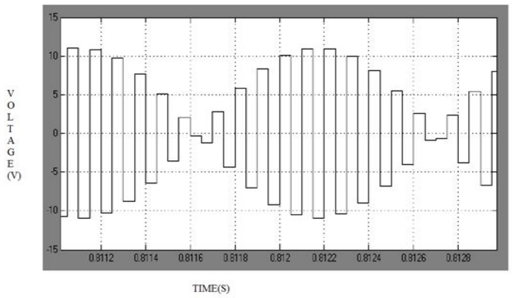

Figure.3.5 voltage waveform of inductor l2

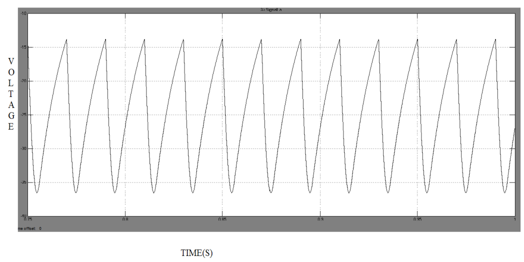

Figure.3.6 voltage waveform of capacitor C

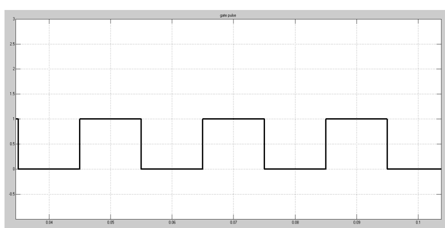

Figure.3.7 Pulses generated for switch S1

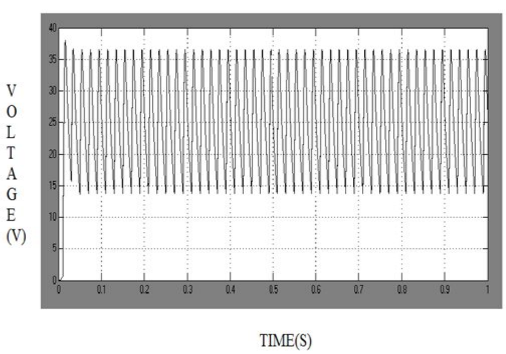

Figure.3.8 output voltage waveform

VI. CONCLUSIONS

A single-switch resonant power converter with an energy-blocking diode has been designed for use in a solar energy generation system. The structure of the proposed converter is simpler and cheaper than other resonant power converters, which require numerous components. The developed single-switch resonant power converter offers the advantages of soft switching, reduced switching losses, and increased energy conversion efficiency. The output power can be determined from the characteristic impedance of the resonant tank by adjusting the switching frequency of the converter. The single-switch resonant power converter is supplied by a solar energy generation system to yield the required output conditions.

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