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COST EFFECTIVE RESONANT POWER CONVERTER FOR SOLAR PHOTOVOLTAIC PLANTS

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Abstract: **The Renewable energy sources are intermittent in nature. In this proposed method; it uses a single Novel single-switch resonant power converter for photovoltaic plants. The developed circuit integrates the Zero current switching (ZCS) and zero voltage switching (ZVS) technique. The blocking diode with direct current output filter filters the output. The proposed circuit uses only one active power for energy conversion which in turn reduces the cost of active power switches and control switches thereby reduces the switching losses. The active power switch is controlled by pulse width modulation at a fixed switching frequency and duty cycle. To achieve ZCS the proposed resonant converter is operated in the discontinuous mode. The proposed resonant circuit is simulated by using MATLAB.**

Keywords- Photovoltaic **(PV) , resonant power converter, Zero-current switching (ZCS), Zero-voltage switching (ZVS).**

I. INTRODUCTION

Nowadays most of the power meets our daily needs from burning of fossil fuels. Owing to increases in consumption, fossil fuel resource may be exhausted in the near future [1]-[3]. In the recent United Nations framework Convention on Climate change which was held in Feb 2015, many developed countries agreed to reduce the consumption of fossil fuels to reduce the green house gases. However India is largely dependent on fossil fuel import to meet its energy demands. About 70% of India's electricity generation capacity is from fossil fuels, with coal accounting 40% of India's energy consumption followed by crude oil and natural gas at 28% and 6% respectively. Environmental degradation and green house gases are becoming serious threat to the whole world. However the renewable energy has become recent trends, following the policy implemented by the Jawaharlal Nehru National solar mission launched on January 10, 2010 by the Government of India ministry of New and Renewable energy. The mission has set the ambitious target of deploying 20,000 Mw of grid connected solar power by 2022 aimed at low cost generation. Accordingly means of renewable energy are being developed. They include wind turbines, photovoltaic (PV) models and fuel cells system [4]-[7].photovoltaic generations have been regarded as the most promising future source of energy because of the following advantages such as, the absence of fuel, low maintenance and lack of noise. India has tremendous scope of generating solar energy. The geographical location of India stands to it's benefits for generating solar power. The reason being India is a tropical country which receives solar radiation almost throughout the year, which amounts to 3000 hours of sunshine. This is equal to more than 5000 trillion kWh.Almost all parts of India will receive 4-7 kWh of solar radiation per sq meters. The Output energy collected from the PV system is utilized as the source of energy. The energy collected will directly connected to the Battery energy storage(BESS),then the output voltage of the source of the photovoltaic plants generation system will be fixed. A dc-dc interface must be installed between the BESS and photovoltaic cells panel to ensure the optimum operation of photovoltaic plants. Power electronics switch is used to transform energy and control power flow. The simplest method of controlling the power electronic switch is pulse width modulation (PWM) [8]-[13]. The PWM technique is used to control the power flow by interrupting voltage or current by switching with the constant duty cycle. When the voltage or current across the power electronic switch is altered suddenly then the approach is said to be hard switching. Due to various advantages like simplicity, relatively, ease of control and low current stress hard switching pwm has been hardly used in modern power electronics converters. The rapid development of technology paves the way for the new power development technologies, as a result of that switch with large switching frequency has developed. Therefore the power converters can operate with high switching frequency, reducing the component size and overall cost of the circuit. However the switching losses will also gets increases in proportion to the switching frequency. The increase in di/dt and dv/dt caused by the increased speed increase the stress on the switch and system electromagnetic interference noise. To improve the switching transition to overcome the drawbacks of hard switching pwm technique various research studies are done in the last few decades. By solving this high voltage stress and current stress problems, energy conversions using resonant power converters should poses high performance.

Resonant converters are nominally used in the application of renewable energy generation systems. The basic requirement of these types of converters should pose high efficiency and small size. The size of the converter can be reduced by increasing the switching frequency. However, the switching losses will also get increases with the switching frequency which in turn reduces the efficiency of the resonant converter. To overcome this problem, some soft-switching technique should be used at higher switching frequencies. The most commonly used soft switching techniques are Zero-voltage switching (ZVS) and Zero-current switching(ZCS) [14]-[19].In this techniques the switching transition occurs either the zero voltage crossing or zero current crossing occurs. It substantially reduces the switching losses and increases the reliability of the resonant converter. The traditional ZVS schemes eliminates the capacitive turn on loss and turn off switching losses by reducing the increasing dv/dt which reduces the overlap of semiconductor switch voltage and switch. The conventional ZCS converters usually operate in the constant on time control. When the converter is operated with switching frequency and variable input source and load makes the filter design complex. This proposed work develops the Single switch resonant converter with ZVS topology based on the traditional ZVS method for photovoltaic plants. The salient features are simple circuit design, ease of control, low switching losses and high energy conversion efficiency.

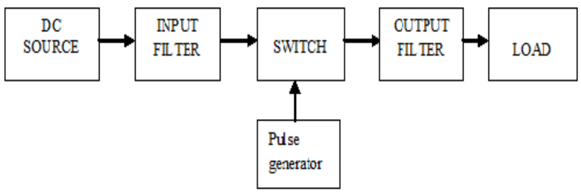

Figure 1: Proposed novel single-switch resonant power converter

The Fig. 1 represents the Block diagram of the single switch resonant converter. The proposed paper presents the novel single switch resonant power converter for photovoltaic plants. unlike conventional ZVS converter, which must have an isolated circuit to trigger the active power switch [20]-[22].The use of single stage resonant converter should provides many advantages such as low number of components, low cost and higher power density. The novel resonant power converter has only one switch which made the converter structure a simpler one, low switching losses and lesser in weight. In addition to that the commutations in the active power switch of the proposed resonant converter are done at zero voltages which results in lower switching losses which lead to higher conversion efficiency.

II.CIRCUIT DESCRIPTION

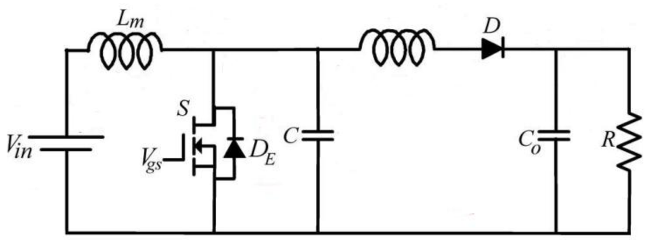

Figure. 2 Basic circuit diagram of the Single switch Resonant converter for Photo voltaic Plants

The above fig. 2 represents the proposed single switch resonant converter. The input voltage is represented as V_{in} is taken from the output voltage of Battery storage system. The Chock inductor L_m and capacitor C which combines together to form input filter. The Mosfet is favoured device and it's used as switch here because its body diode can be used as antiparallel diode D_E for a bidirectional switch. The capacitor C_o and Resistor R together formed a first order low-pass filter which reduces the ripple contents present in the voltage than the specified level.

III. SIMULATION OF OPEN LOOP SINGLE SWITCH RESONANT CONVERTER AND CLOSED LOOP SINGLE SWITCH RESONANT CONVERTER.

The proposed single switch resonant converter input is taken from the small photo voltaic plants. Based on the method of giving input voltage to the converter it's differentiated into two types. They are Open loop control and Closed loop control method.

- The various parameters of the resonant converter is compared between the open loop and closed control. The Simulink diagram of proposed resonant converter is drawn using the MATLAB SIMULATION™

A. OPEN LOOP CONTROL METHOD.

In the open loop control method where the input voltage is taken from the solar panel storage system 12V is given as input to the resonant converter. Based on this input various parameters will be measured across the various components present in the system. The fig. 4 represents the open loop model of the single switch resonant converter.

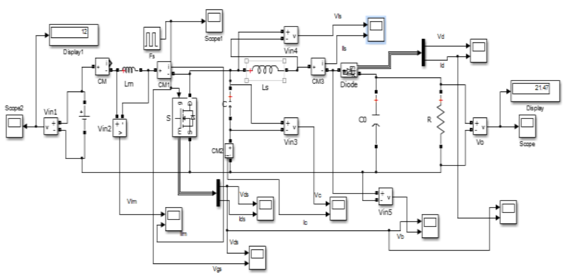

Figure 4 simulation of Proposed open loop Resonant converter

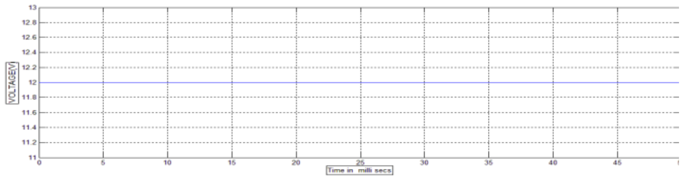

Figure 5 input supply voltage of the Proposed open loop Resonant converter

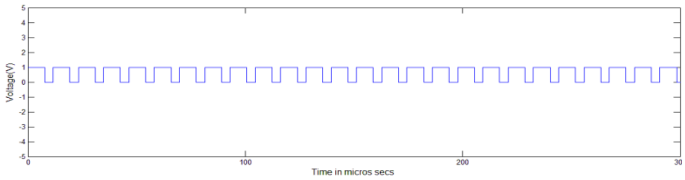

Figure 6 gate pulse of the Proposed open loop Resonant converter

The fig.5 represnts the input voltage of the system and X axis and Y-axis of the graph represents time preriod in milli secs and voltage(V).The fig. 6 represnts the Gate pulse given to the circuit.The Y axis represnts the voltage(V).

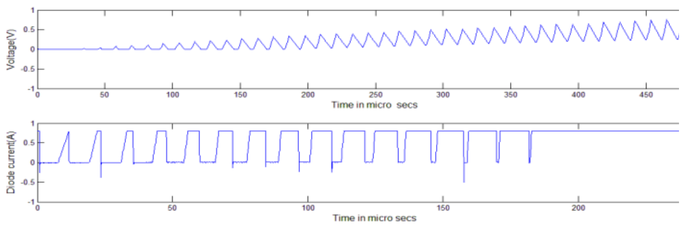

Figure 7 Diode voltage and current of the open loop Resonant converter.

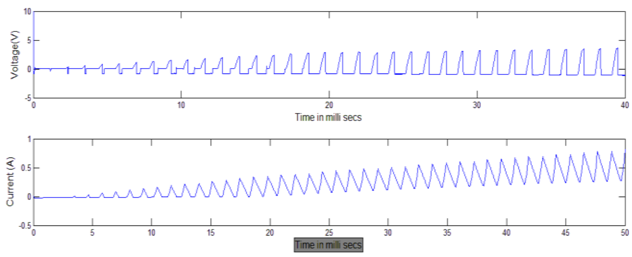

Figure 8 choke voltage and current of the open loop Resonant converter.

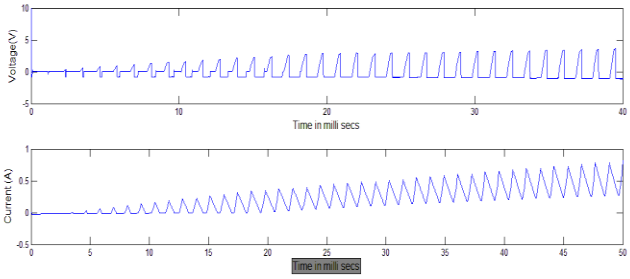

Figure 9 voltage and current parameters of the Ourput filter inductor of the open loop Resonant converter.

The fig.7 represents the voltage across the Blocking diode (D) and current flowing in the diode. Fig. 8 represents the voltage and current parameters of the Choke inductor (L_m). The fig. 8 represents the voltage and current parameters of the output filter inductor.

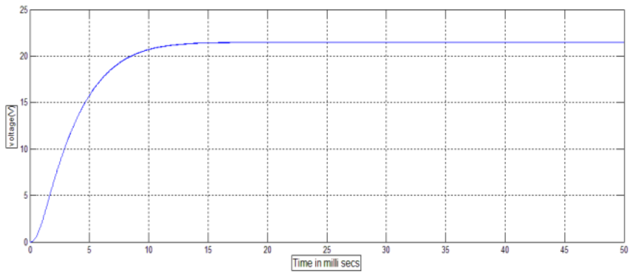

Figure 10 Output Voltage waveform of the open loop Resonant converter.

The fig. 10 represents the output voltage waveform of the open loop converter.For a given input voltage of 12V the output should be 21.4V.

B.CLOSED LOOP RESONANT CONVERTER

In the closed loop control method the Output of the Solar pv plants is directly fed to the proposed resonant converter.The initial input voltage given to the system is 12V and after some time period the Supply voltage will be increased drastically to 18V. Here the Output voltage is taken as feedback and it is compared with the reference voltage 34V and based on the difference in voltage the error signal is generated.The generated error signal is given to the

PID controller and based on the error the gate pulse will be generated here and it's given to the Switch (S).The fig. 10 represnts the Closed loop resonant power converter.

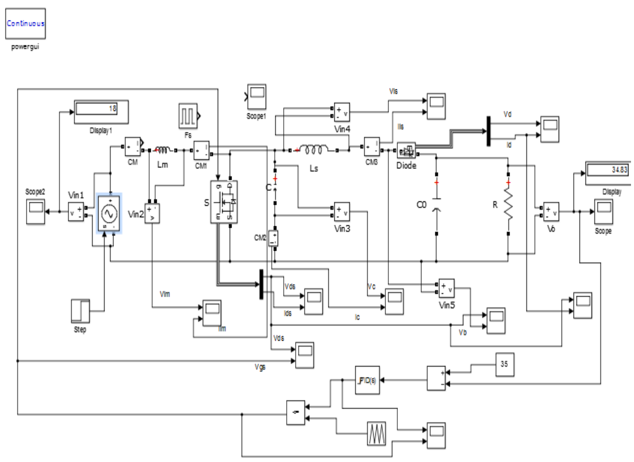

Figure 10 simulation of Closed loop resonant power converter.

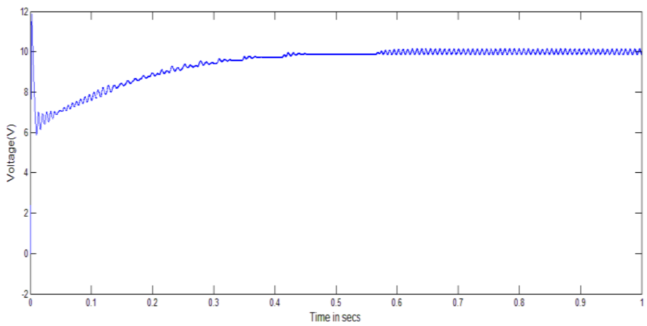

Figure 11 Output voltage of Closed loop resonant power converter.

Fig. 11 shows the output waveform of the closed loop converter. The output voltage of 34V will be maintained throughout the entire operation of the system.

III .CONCLUSION

In this proposed method, the ultimate aim is to develop the single switch resonant power converter with a blocking diode for the photovoltaic generating plants. The structure of the proposed converter is analyzed by simulating the circuit in matlab and various parameters are measured. The proposed resonant converter offers the advantages of such as low switching losses due to soft switching technique and higher conversion efficiency. The Single switch resonant output power can be varied by varying the switching frequency of the Mosfet. The proposed converter will give higher efficiency on comparing with conventional class D converter with few circuit components and at low cost.

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