International Journal of Engineering Research and Development
e-ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com
Volume 9, Issue 11 (February 2014), PP. 57-62

Photovoltaic Multi-String Boosted Converter for Grid Applications

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Abstract:- As the demand for electrical energy is increasing, renewable energy sources has come into popularity especially photovoltaic systems (PV).This paper presents an overview of the power converters that are adopted in Photovoltaic generation systems. This paper deeply analyses both converter configurations also taking into consideration the control aspects connected to the grid of such systems.In the proposed model photovoltaic cells are connected in a multi-string manner, then it is boosted up and connected to common dc bus, in the next stage boosted dc voltage is converted to ac by inverter. Nowadays micro-controllers are used to control how many PV cells are to be operated, according to the conditions. Soft switching methods are adopted in order to shape the rising and falling edges of switches switch current and voltage. String conversion configuration based on several DC/DC converters connected to high voltage DC bus and linked to a single DC/AC converter appear as more complex solution but offer higher efficiency. MATLAB software is used to simulate the model. Almost completely, the requisites that make effective any reduction of energy consumption is based on power electronics.

Keywords:- Photovoltaic (PV), Pulse Width Modulation(PWM), Total Harmonic Distortion(THD)

I. INTRODUCTION

The ever increasing energy consumption has created a booming interest in renewable energy generation systems, Any effort to reduce the CO2 usage is making use of power electronics. By 2030 it is estimated that 30% of global electricity is produced from renewable energy sources such as wind, solar[1].Nowadays the technology used is string inverter[2], where DC voltage is produced from solar cell, and it is converted to AC at the end of each solar module, and AC is boosted up to the required voltage level and injected into the grid. In this paper new topology is introduced multi-string inverter topology which offer higher efficiency. in multi-string inverter topology DC voltage boosted up initially and converted into AC. PWM is introduced for better control of gate pulse. LC filter is introduced to get smoothen the output waveform. This method offers number of advantages

II. PROPOSED CIRCUIT CONFIGURATION

The diagram of new multi string inverter is shown in the figure. large number of PV modules are connected in series to form a string to get the required output voltage level, and these strings are connected in parallel through the interconnection of diodes.

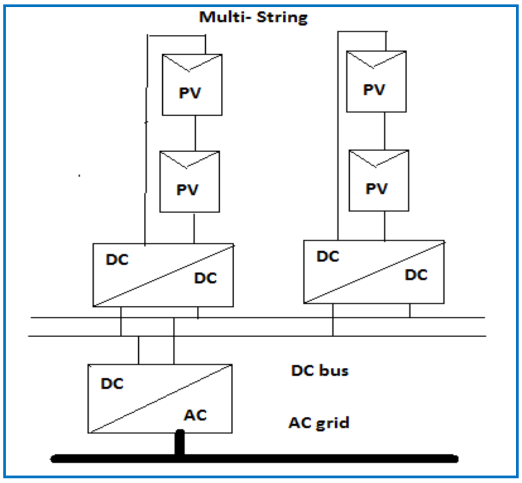


Fig.1: Multi-String Inverter

since the output of PV cell is DC voltage[7,8,9], PV cell is represented by DC voltage sourceIn this topology at the end of each string DC voltage is boosted up to the required common DC bus voltage[4]. Only at the end DC is converted into AC voltage. Even though it seems to be complicated it offers high efficiency and also helps to avoid losses.

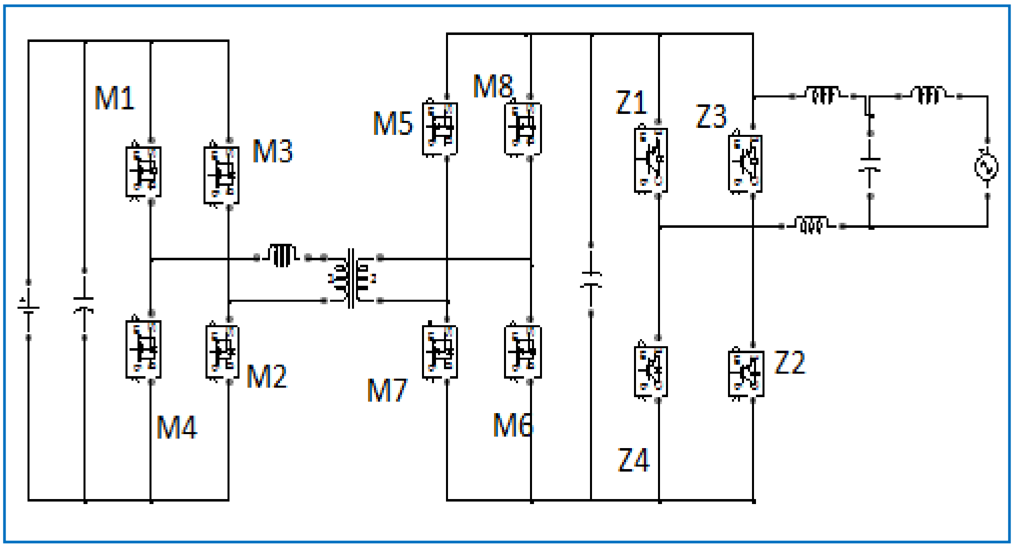


Fig. 2 : Zvs Full Bridge Dc/Ac Converter

The above given figure shows the circuit implementation of typical PV unit in the multi string inverter. since the output of PV cell is DC voltage, PV cell is represented by dc source. When switches M1 and M2 are ON current from the source flow through M1, coupling inductor then through primary of transformer, then through M2 then to the source and completes the closed path. According to the frequency needed at the output, switching frequency is adjusted so that pulse to the next set of switches is delayed, for a frequency of 50 Hz 0.02 second delay is given. In the secondary due to transformer action emf induced. Initially M5 and M6 are turned on. After a delay M7 and M8 are turned ON. So that boosted DC voltage is available across the capacitor.

In the next stage DC to AC inverter action will takes place. Initially Z1 and Z2 is switched ON, after a delay according to the frequency of the output voltage Z3 and Z4 are turned ON. So that will get a AC voltage at the output.

Even though continues improvement is taking place in the field of power semi-conductor devices still suffering from hard switching losses. Solution to this problem is soft switching technique which can shape the rising and falling edge of voltage and current smooth. Two soft switching technique here used is Zero voltage transition (ZVT) and Zero current transition (ZCT). Advantage of soft switching technology is that it reduce losses thereby increasing efficiency, it also helps to achieve high performance in terms of wide control of band width, high power density, and low THD which are the problems faced in a high switching frequency circuits. Another advantage of this circuit is the absence of parasitic effects due to high frequency transformer leakage inductance. As a result snubber circuits can be avoid thereby reducing overall cost and size of the circuit.

From power loss calculation and voltage and current ratings, at the design stage of the converter 47A, 650 V MOSFET devices were selected for DC/DC converter featuring 60mΩ R_{dson} and 30A, 600V IGBTs were adopted for DC/AC converter stage. Each device are connected parallel to a fast soft recovery diode. Efficiency maximization of the converter can be achieved by high input voltage and low input current due to sensible reduction of conduction losses.

III. CLOSED LOOP CONFIGURATION

In order to increase the performance of the system closed path is provided. PI controller is used for controller purpose.The above figure shows the closed loop configuration of inverter using PI controller, with Kp=0.5 and Ki=99. Pulse is created with the help of relational operator. Direct output of relational operator is given to pair of gates (M1 and M2) and inverted pulse is given to another pair of gates (M3 and M4). Reference voltage is set as nominal rms value of the grid voltage. By closed loop configuration we can limit the maximum voltage under a particular value say 230 volt.

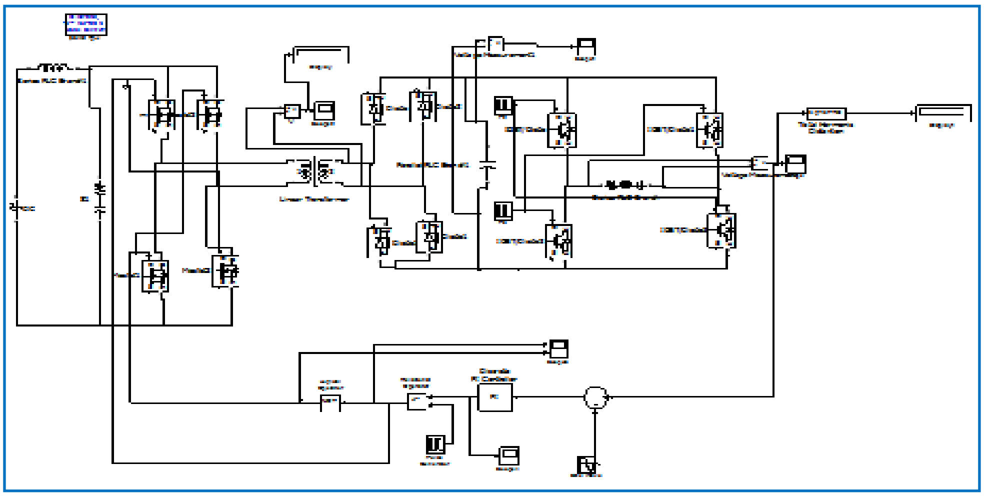


Fig. 6 : Simulink Model Of Closed Loop PV Fed Dc/Ac Converter

IV. HIGH EFFICIENCY DC/DC BOOSTING CIRCUIT

Design techniques of PV panel may change according to applications, efficiency and voltage gain are the two most important factors. High voltage gain can be obtained by charge pump system or high frequency transformer. New high efficiency circuit is introduced for boosting up of DC voltage is introduced[4].

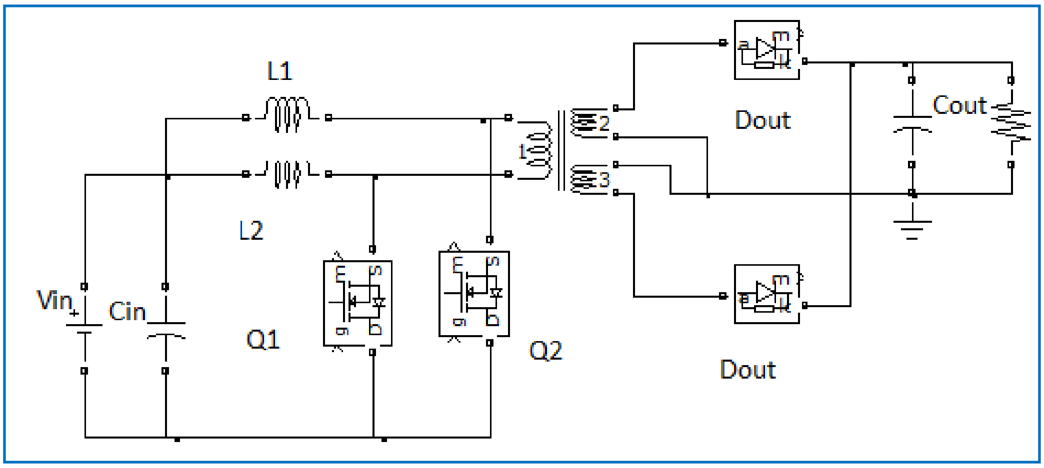


Fig. 7 : Boost Interleaved Converter With Hf Transformer

Standard interleaved PWM technique is used as switching technique. Both switches have same switching frequency and duty cycle so that ripple of input current can be reduced. Initially Q1 is switched on, inductor charges when Q1 is switched off current flow through transformer, emf induced in the secondary will forward bias the diode output capacitor charges. Same procedure is repeated for swich Q2 also. Therefore get boosted output voltage at the load according to turns ratio of transformer.

Efficiency is calculated using Californian-ponderationequation..

$$\eta cec = 0{,}04 * \eta 10\% + 0{,}05 * \eta 20\% + 0{,}12 * \eta 30\% + 0{,}21 * \eta 50\% + 0{,}53 * \eta 75\% + 0{,}05 * \eta 100\%$$

Table 1: specification of converter for PV panel

Converter	**Classic transformer**
Efficiency	95 %
Switch	2
Max V stress	Vout/n
Max I stress	In/2
V stress on diode	2 Vout
I stress on diode	In/2n
Diode	2

V. PWM MODULATION

In order to get more control, instead of pulse generator one of the method that can adopted is PWM. Required gate pulse is obtained by comparing triangular wave signal of fundamental frequency with a constant signal of magnitude 0.75.comparison is done with the help of relational operator. Direct output of PWM generator is given as gate pulse to M1 and M 2 and inverted output is given as gate pulse to remaining switches M3 and M4.

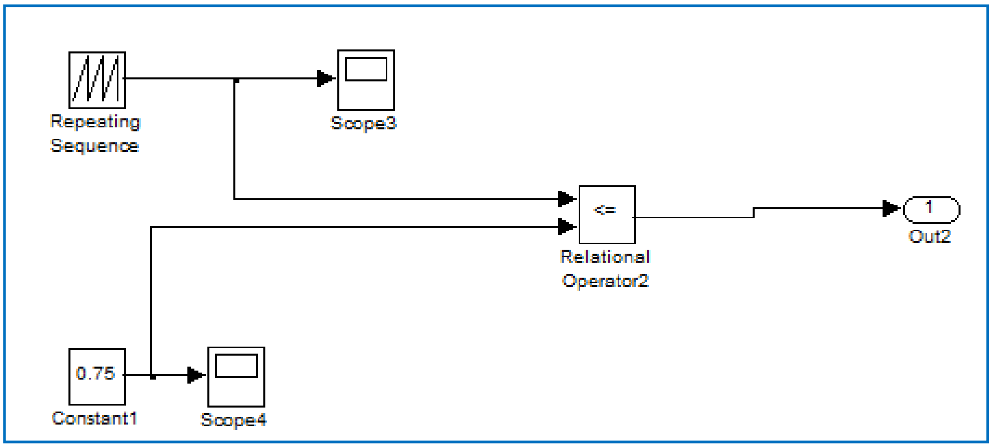


Fig. 8 : Simulink Model Pwm Generator

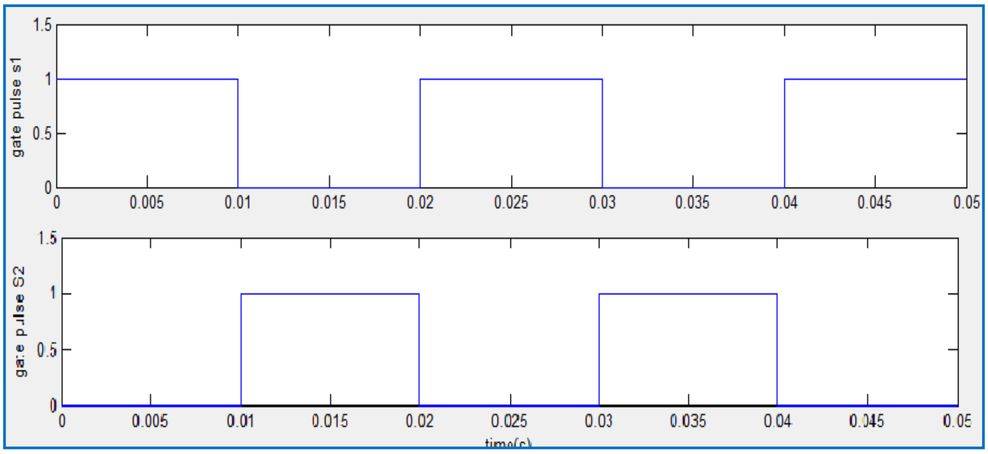
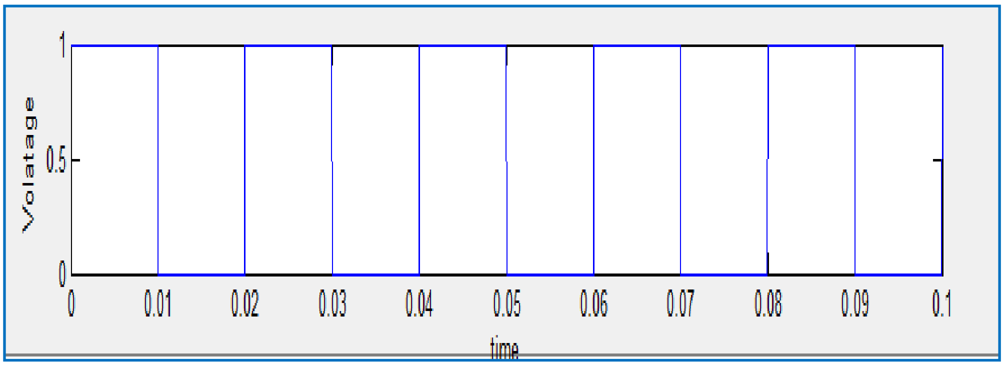


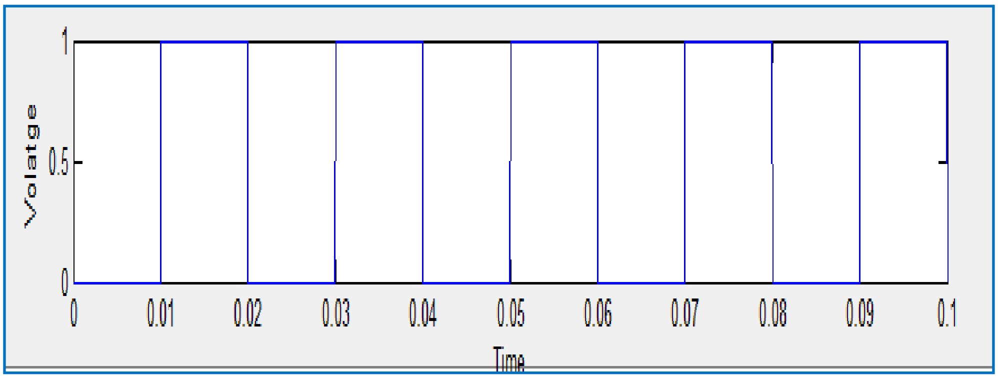
Fig. 9: Gate pulses to M1, M2 pair and M3, M4 pair

VI. SIMULATION RESULTS

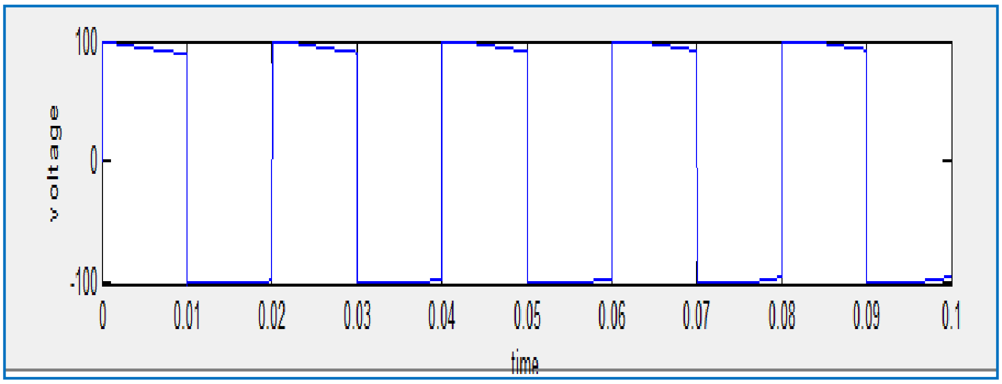
The simulation of the proposed PV multi-string boosted converter done with the help of MATLB SIMULINK. Fig. 8 shows the PWM modulation generated gate signals for M1-M2, M3-M4 respectively. Simulated waveforms of output voltage is for an input voltage of 100v with load resistance R=100Ω, L=50H, C=1µF are obtained as shown in figure 13.



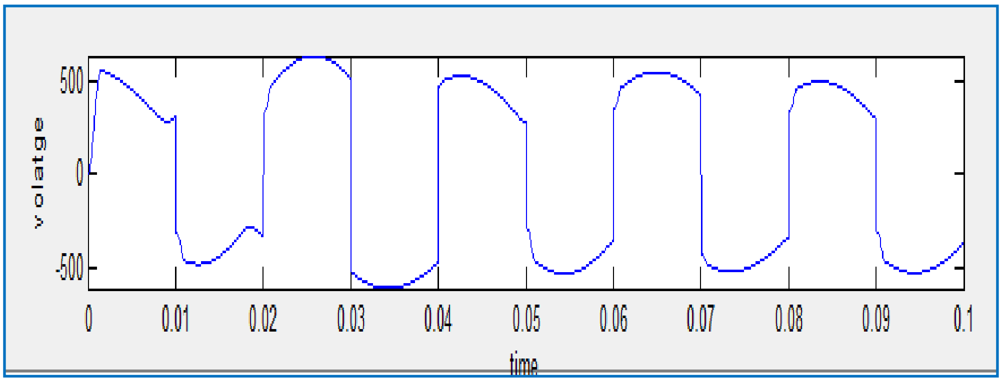
(a)



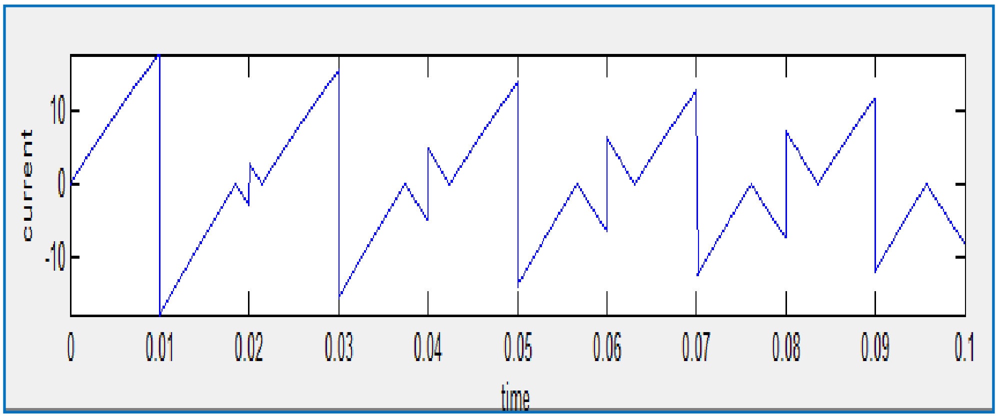
(b)



(c)



(d)



(e)

Fig.10: (a) Gate pulse toSwiches S1, S2 **(b)** Gate pulse to Switches S3,S4 **(c)** Voltage on primary side of transformer **(d)** Output voltage injected into the grid **(e)** Output current

VII. CONCLUSION

In case of solar energy, which is converted into electrical energy which is injected into the grid, in which power converters play a crucial role which also offer higher efficiency with the aim of showing how important can be the contribution of power electronics in this area. This paper has presented standard and advanced converter topologies that have been compared according to such performance parameters as efficiency, cost and reliability, advantages, limitations and possible applications of the presented configurations have been indicated within the two classes of identified power converters. After all comparing the existing topology with the multi-string inverter topology,we can implement it as a better efficiency topology. From time to time power demand is different. During peak load require more power, so that more PV cells have to accompany the operation. Other than converter efficiency there are international standards regarding distortion factor, power factor, anti-islanding factor etc, and sophisticated algorithms have to employ complex computations of PWM techniques. All these factors cannot control easily by human operator. This leads to necessity of using micro-controller. Recently it has been shown that these complex calculations can be reduced to that of standard micro-controller[11].The proposed circuit which is described above can be implemented by micro-controller 32 bit CORTEX-M3 which can perform 90 MIPS (million instructions per second).

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