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CURRENT FED FULL BRIDGE SOFT SWITCHING GRID CONNECTED SOLAR BASED PUSH PULL INVERTER

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ABSTRACT

This paper proposes the Current fed full bridge soft switching grid connected solar based push pull inverterwith high efficiency and good transient and dynamic response. This paper also aims to formulate a comparative study of the conventional open loop &proposed method and its performance analysis is done by the use of MATLAB. Compared to the conventional method, full bridge rectifier is used to improve high output power. In critical loads, the time domain specifications play a major role which otherwise damage the system performance. Thus, the analysis is made from the conventional and proposed converter with PWM pulse technique current fed push pull grid inverter. Circuit simulations and experimental results are shown to have excellent agreement with the fundamental analysis.

Keywords: DC/AC grid inverter, PV array, MATLAB/Simulink,PWM pulse, ZVS.

1. INTRODUCTION

Industrial applications requiring converters of minimum losses and improved efficiency, has led to the wide use of soft switching of power electronics converters, which is also been proved. The important performance parameter in power electronics devices is high power density. Increasing switching frequency is the only effective way to improve power density. Switching losses will be increased on increasing the switching frequency. In low input voltage system conduction loss is the important consideration .Hence the study of current fed push-pull converter was proposed. Soft switching i.e. ZV and ZC switching methods are given in [1, 2].This converter was proposed in order to decrease the weight of the DC/ AC grid inverter. ZC resonant current fed push-pull converter is introduced in [1].An LC resonant current fed Push-Pull converter was developed to turn on and turn off the primary and secondary switches by ZV and ZC condition [2], since most of the resonant current will be flowing through the output capacitor to control the ripple of output voltage. But this resonant converter leads to large voltage stress and higher conduction loss which are difficult to control.

To overcome these disadvantages Bi-directional DC-DC converter with natural ZVS was incorporated with minimum number of switching devices [3]. Also high power density, simulation and experimental verifications are given in [4].Modelling, Control, and Simulation of Battery Storage Photovoltaic-Wave Energy Hybrid Renewable Power Generation Systems for Island Electrification in Malaysia are presented in [5]. The output voltage is more oscillatory and with more peak overshoot. These disadvantages are overcome by the design of resonant converters for variable energy transfer and regulation of output voltage. The conventional methods such as state space averaging has been adopted successfully in modeling (PWM) switching converters [6], but it was proved ineffective with resonant converters. Since transient and dynamic responses of DC/AC grid inverter for critical loads are very important, the design and choice of controller in resonant converter play a vital role in the study of proposed converter.

In most of the cases due to high bandwidth and relatively low cost we use analog controllers. For design and implementation of complex control algorithms using an analog controller is a very difficult task. Even though digital controllers are used for implementing complex control algorithm [7, 8] they are less sensitive to environmental factors and parameter variations. Also very flexible with fewer electronic components, simple integration and real time implementation.

The conventional method generating more ripple and high THD is widely employed in industrial applications because of its simplicity, clear functionality and feasibility. Nowadays, a two-stage conventional configuration is usually adopted in the PV inverter systems. Each MPPT is realized with a current fed push pull converter to step up the PV-array voltage close to the specified DC-link voltage, as shown in Fig. 2. When the PV-array voltage is higher than the DC-link voltage, the boost converter is operated in by-pass mode. However, when the PV arrays characteristics are different from each other, the inverter operated in by-pass mode cannot track each individual point of MPP accurately, and the inverter suffers from high-voltage stress as the open voltage arrays. To release the limit, an MPPT topology combining buck and boost converters is proposed, in which the control algorithm for tracking maximum power points based on a perturbation and observation method is used.

The MPPT will change the operation modes between buck and boost when the DC-bus voltage is nearer to the output voltage of a PV array. The designed controller can be used to achieve smooth mode transition and fulfill online configuration check for the MPPTs, which can be either separate or in parallel connection, to draw the maximum power more effectively from the PV arrays. Additionally, a uniform current control scheme is introduced to the controller to distribute output current equally from PV array to the two MPPTs in parallel operation [14]. This FLC has replaced the conventional controllers in many industrial applications. Fuzzy Logical

Algebras and their applications are utilised from [15, 16].In this new topology has been proposed in order to supply the critical loads. The ZVS current fed Push-Pull DC/AC 12V/80V converter with high step up gain was designed and a proper controller has been suggested to get good transient and dynamic response.

The paper is well organized as follows. In section II the operation of proposed current fed Push-Pull DC/AC grid inverter operation is discussed. The section III describes the simulation results of current fed Push-Pull DC/AC converter with conventional and proposed system. In section IV, Experimental analysis of the proposed converter justifies the simulation results. In section V, the conclusion of the proposed work is described.

2. CURRENT FED PUSH-PULL DC/AC GRID INVERTER

The switching regulator is increasing in popularity because it offers the advantages of higher power conversion efficiency and increased design flexibility. A two-Transistor converter is employed that is especially efficient at low input voltages.

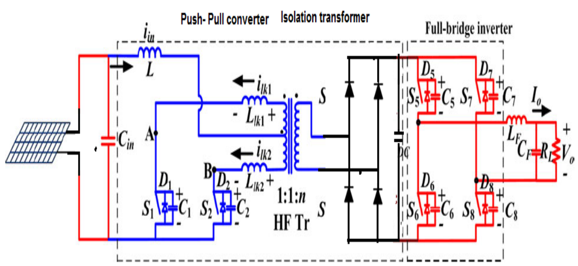

Figure-1(a). Push-pull converter.

Figure-1(a) shows the Push-Pull converter which is operated by alternatively switching on the two transistors. Current flows in the secondary of the transformer at the same time as current flows in primary. When transistor A is switched ON, the input voltage is forced across the upper part of the primary winding with dotted negative terminal. On secondary side a negative voltage will appear across the windings which forward bias the second diode. This allows the current to flow through the inductor to supply both output capacitor and load. If transistor B is switched ON, the input voltage is forced across the lower part of transformer primary winding with positive dot polarity. Thus the same voltage will appear across the secondary winding which will forward bias the first diode. This allows the current to flow through output capacitor and load. The most important characteristics of a Push-Pull converter are that the switch is able to stand off more than twice the input voltage. Due to “double input voltage” rating requirement Push-Pull converter is best suited for lower input voltage applications. Hence it has been widely used in converters operating in 12V battery powered systems.Figure-1(b) shows the timing diagram which gives the relationship of input and output pulses. It is very important to see that the frequency of secondary voltage is twice that of frequency of operation of PWM controller.

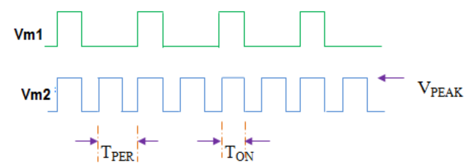

Figure-1(b). Timing diagram of current fed push-pull converter.

The DC output voltage is given by

$$Vout = Vpk * \left(\frac{Ton}{Tper}\right) \tag{1}$$

Where Vpk=peak amplitude of the secondary pulses

$$Vout = (Vin - Vswitch) * \left(\frac{Ns}{Np}\right) - Vrect \tag{2}$$

This shows that the current fed Push-Pull converter is well-suited for low voltage converter. The voltage forced across each of the primary winding which provides the power conversion is the full input voltage on subtracting the voltage of the switch. In

Proposing current fed Push-Pull DC/AC converter transistor switch is replaced by MOSFET power switches in order to reduce the voltage drop across the switches to extremely small results in higher utilization of input voltage.

3. SIMULATION RESULTS CONVENTIONAL AND PROPOSED METHOD DISCUSSION

3.1 Design and analysis of pv based current fed push-pull dc/ac grid inverter

Simulink model for current fed Push-Pull DC to AC grid inverter open loop simulation is designed and simulated.Figure-2 shows the model of current fed Push-Pull DC/AC inverter closed loop system. Figure-2 shows the Simulink model of solar panel. Table-1 show the parameter used in the design of PWM controller in the open loop. From the 12V input voltage the output is sensed and it is increased to 100V. Then processed using a PWM controller.

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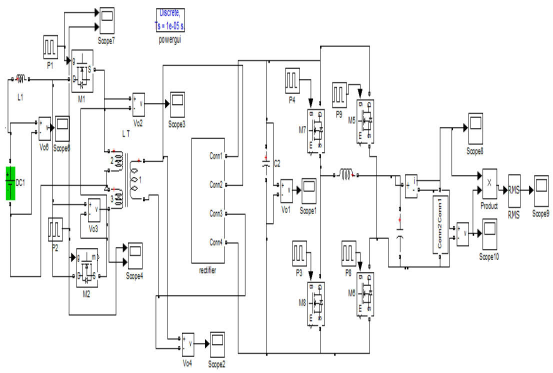

Figure-2. Simlink model of conventional current fed Push-Pull DC/AC Grid inverter.

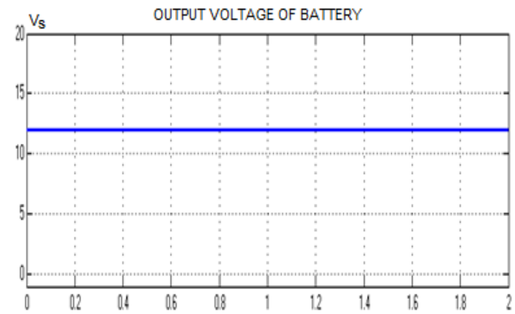

Figure-3. Output voltage of battery.

Using PWMcontroller, pulses or generated and is feed MOSFETat M1, M2, M3 and M4 switched according to the pulses shown inthe figure. repetitively MOSFET are switched on and off. Hence The inverter gets the output voltage at an average of 12v as shown in Figure-2. The on state voltage von across the MOSFET also measured as shown in the figure.

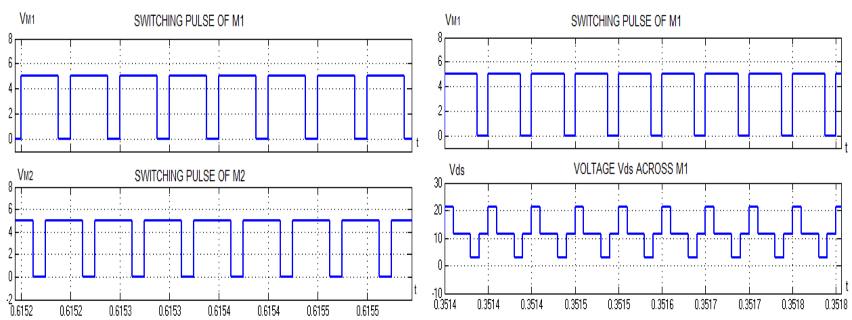

Figure-4. Switching pulse for M1, M2 and switching pulse M1andVds.

The increase in the output voltage is nullified by reducing the pulse width applied to the MOSFET of the controlled converter.Here, a conventional PWM controller as the simplest open-loop is designed to determine the firing angle to control the output voltage. For this purpose, first, the voltage error signal, which is the difference of the reference and measured voltages, is determined by Equation (3).

$$e = V_{ref} - V_{meas} \quad (3)$$

Where Vref is reference voltage and Vmeas is the actual measured output voltage

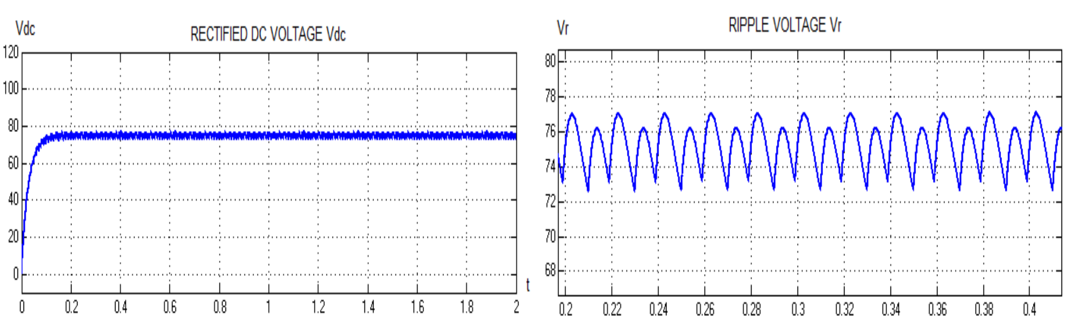

Figure-5. Half bridge rectified output voltage and Ripple voltage (5.8v).

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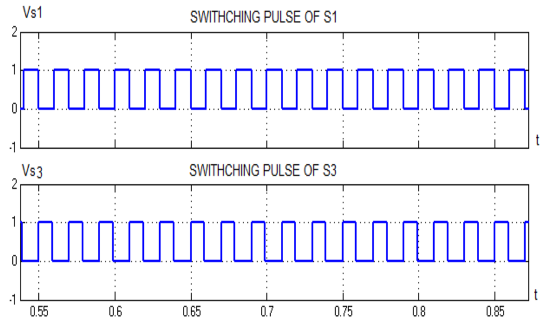

Figure-6. Switching pulse for inverter S1, S3.

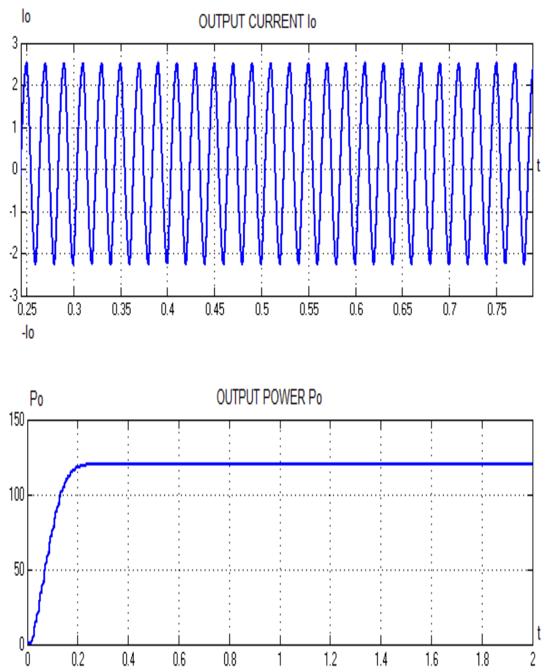

Figure-7. Output current and Output power.

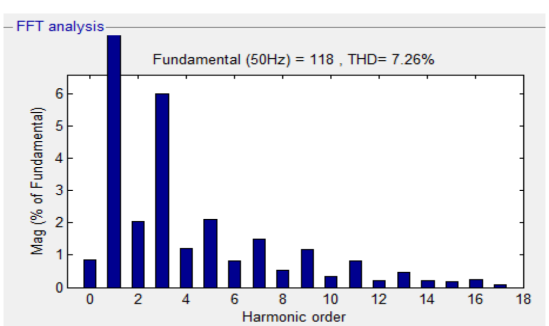

Figure-8. THD.

The total harmonic distortions are measured for both the full wave and half wave inverter. It is measured as7.26% for half wave its first order and third order harmonic are higher compare to the superior the respective harmonic pulse width modulation techniques and involve in the proposed current fed push pull inverter.

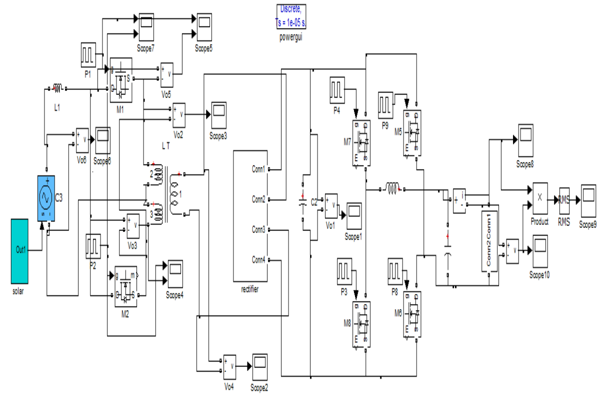

Figure-9. Simulink model of proposed current fed Push-Pull DC/AC with Grid inverter.

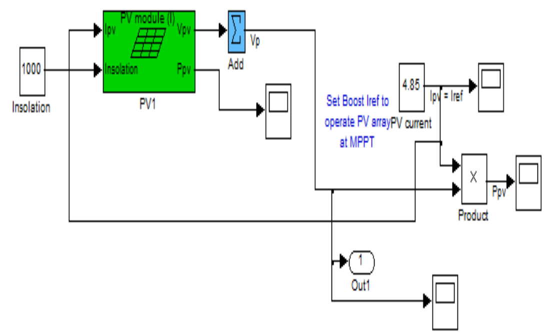

Figure-10. Solar model.

In this proposed current fed push pull DC and AC inverter, in order to reduce the THD. PWM technique is used. By this way the width of the pulses are reduced which was fed to the respective switch as shown in the fig. Due to the reduction in pulse width the on state voltage drop at the switches also reduced.

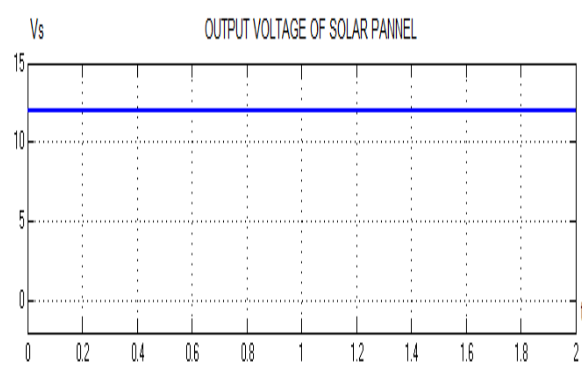

Figure-11. Output voltage of solar.

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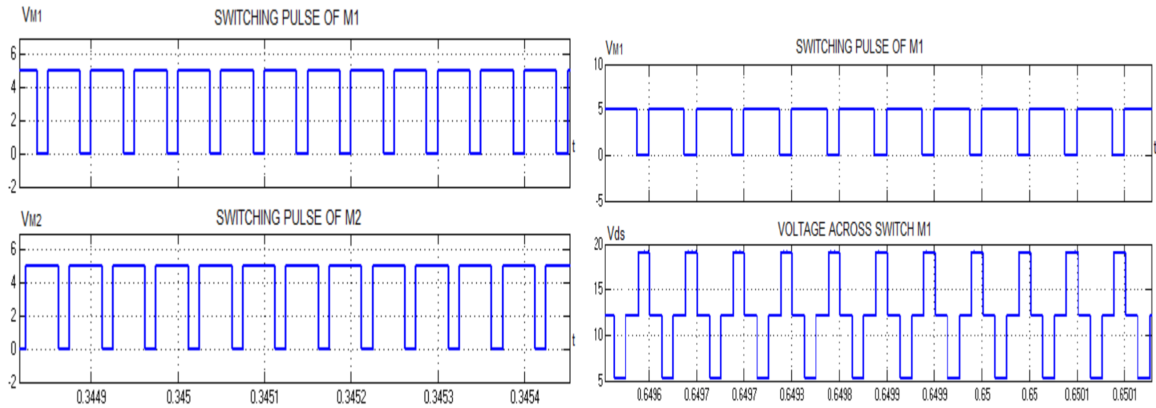

Figure-12. Switching pulse M1, M2 and switching pulse M1 and Vds.

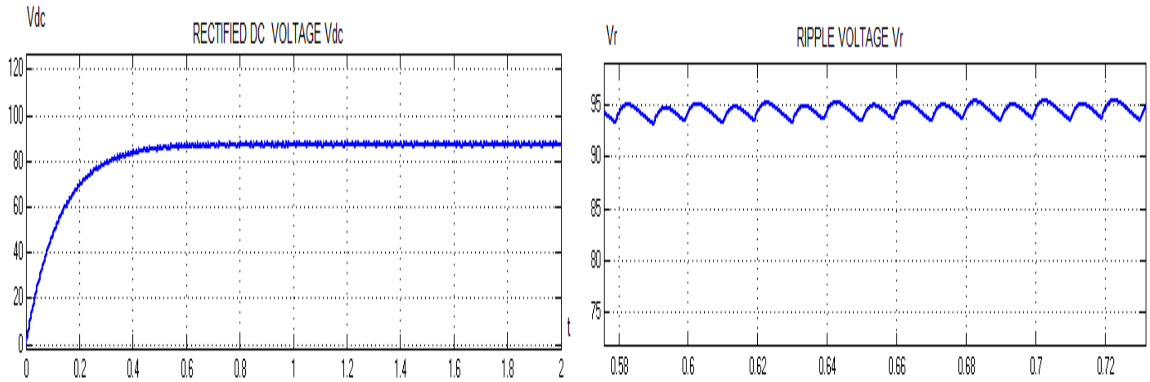

Figure-13. Full Bridge rectified output voltage and Ripple voltage (2.4V).

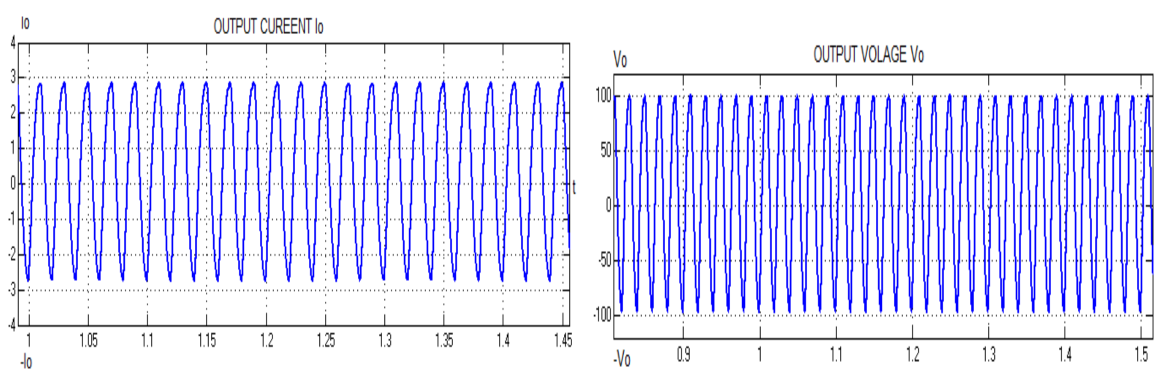

Figure-14. Output current and voltage.

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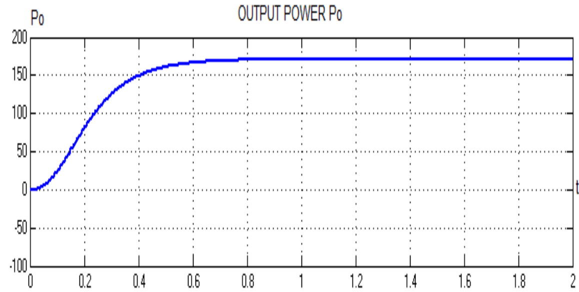

Figure-15. Output power.

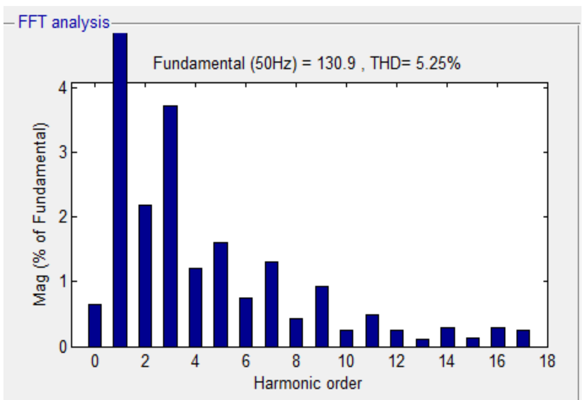

Figure-16. THD.

Table-1. Comparison of current fed push pull grid inverter.

Push pull converter	Vin	Rectifier output voltage	Inverter output voltage	Output current	Output power	THD
conventional	12v	60v	80v	2.5A	130W	7.26%
proposed	12v	90v	100v	3A	170W	5.25%

Table-2. Parameters used in the simulation studies.

Parameters	Value
V_s (input voltage)	12V
V0	100V
F_s (switching frequency)	20KHz
L_1 and	2.6mH
C(capacitance)	20µF
R (load resistance)	500Ω

4. CONCLUSIONS

The conventional method is generating more ripple voltage and low output current. The proposed method produces reduced voltage ripple and increased output current. The proposed method performs well when compared to the conventional method and the comparison results are given in discussion Table-1. The following the simulation results are studied. The comparison with closed loop will be done in future.

REFERENCES

[1] Boonyaroonate. I and Mori. S. 2002. A New ZVCS Resonant Push-pull DC/DC Converter Topology. Applied Power Electronics Conference and Exposition, 2002. APEC 2002. Seventeenth Annual IEEE. pp. 1097-1100.

[2] E. Deschampsand I. Barbi. 2000. A flying –capacitor ZVS 1.5KW DC to DC converter with half of the input voltage across the switches. IEEE Transactions on Power Electronics. 15(5): 855-860.

[3] J.S. Lawler. 2001. A natural ZVS high-power bi-directional DC-DC converter with minimum number of devices. Industry Applications Conference, 2001. Thirty-Sixth IAS Annual Meeting. Conference Record of the 2001 IEEE. p. 187.

[4] A. Nami, F. Zare, A. Ghosh and F. Blaabjerg. 2011. A hybrid cascade converter topology with series-connected symmetrical and asymmetrical diode-clamped H-Bridge cells. IEEE Trans. Power Electron. 26(1): 51-65.

[5] S. Dwari and L. Parsa. 2011. An efficient high-step-up interleaved dc-dc converter with a common active clamp. IEEE Trans. Power Electron. 26(1): 66-78.

[6] J.-M. Shen, H.-L. Jou and J.-C. Wu. 2012. Novel transformerless grid connected power converter with negative grounding for photovoltaic generation system. IEEE Trans. Power Electron. 27(4): 1818-1829.

[7] T. Kerekes, R. Teodorescu, P. Rodriguez, G. Vazquez and E. Aldabas. 2011. A new high-efficiency single-phase transformerless PV inverter topology. IEEE Trans. Ind. Electron. 58(1): 184-191.

[8] S. V. Araujo, P. Zacharias and R. Mallwitz. 2010. Highly efficient single-phase transformerless inverters for grid-connected photovoltaic systems. IEEE Trans. Ind. Electron. 57(9): 3118-3128.

[9] Farhad Aslam and Gagandeep Kaur. 2011. Comparative Analysis of Conventional, P, PI, PID and Fuzzy Logic Controllers for the Efficient Control of Concentration in CSTR. International Journal of Computer Applications (0975 -8887). 17(6).