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# REVIEW OF SOLAR POWER GENERATION WITH SEVEN-LEVEL INVERTER

Mr. Satish N. Ghorpade
*Yadavrao Tasgoankar Institute of Engineering and Technology, Karjat*

Prof. Gopal Chaudhari
*Yadavrao Tasgoankar Institute of Engineering and Technology, Karjat*

Mr. Vaibhav Kharat
*All India Project Consultant Ltd.*

## ABSTRACT

Multilevel Inverter, specially cascaded H-bridge type is becoming more applicable now-a-days due to their improved voltage and current waveforms. This system is composed of dc/dc power converter and a new seven-level inverter. The dc/dc power converter integrates a dc-dc boost converter and a transformer to convert the output voltage of the solar cell array into two independent voltage sources with multiple relationships. Seven level inverter is configured using capacitor selection circuit and a full-bridge power converter, connected in cascade. The capacitor selection circuit convert the two output voltage sources of dc-dc converter into a three-level dc voltage, and full bridge power converter further converts this three-level dc voltage into a seven-level ac voltage. Likewise sinusoidal output generated which is in phase with the utility voltage and fed into the utility. The salient feature of above converter is it require only six power electronic switches and only one power electronic switch is switches at high frequency at any time. In this paper review of seven level invertor has been done.

**KEYWORDS-** Multilevel Inverter, H-bridge Inverter, Pulse-width Modulated (PWM) Inverter

## INTRODUCTION

Contributed Solar energy is becoming more important now-a-days due to reduction in supplies of non-conventional energy sources. Along with less pollution, cost of solar array is also decreasing day by day. Solar energy is always better in residential applications in near future. Solar cell generates DC power which should be converted in AC power before feeding it to utility grid. Inverter is used as power conversion interface here. Dc-Dc power converter is used in small capacity solar power generation to boost the generated voltage to match the bus voltage of inverter. The active and passive devices in inverter leads to power loss like conduction loss due to active devices and switching loss.
Multilevel inverter technology should be designed with higher voltage levels in order to improve the conversion efficiency and reduce harmonic content and electromagnetic interference. Conventional multilevel inverter includes following topologies:

1) Diode-clamped
2) Flying capacitor
3) Cascade H-bridge

First two topologies use capacitor to develop several voltage levels. But it is difficult to regulate the voltage of these capacitors also power circuit is complicated. For a single phase seven-level inverter, 12 power electronic switches are required in first two topologies. In cascade H-bridge inverter two H-bridge inverter with DC bus voltage of multiple relationship can be connected in cascade to produce single phase seven level inverter and eight power electronics switches are used only. So cascade H-bridge inverter is suitable for applications with increased voltage levels. Recently, various novel topologies for seven-level inverter have been proposed. For example single phase seven level grid connected inverter which use only six power electronic switches.

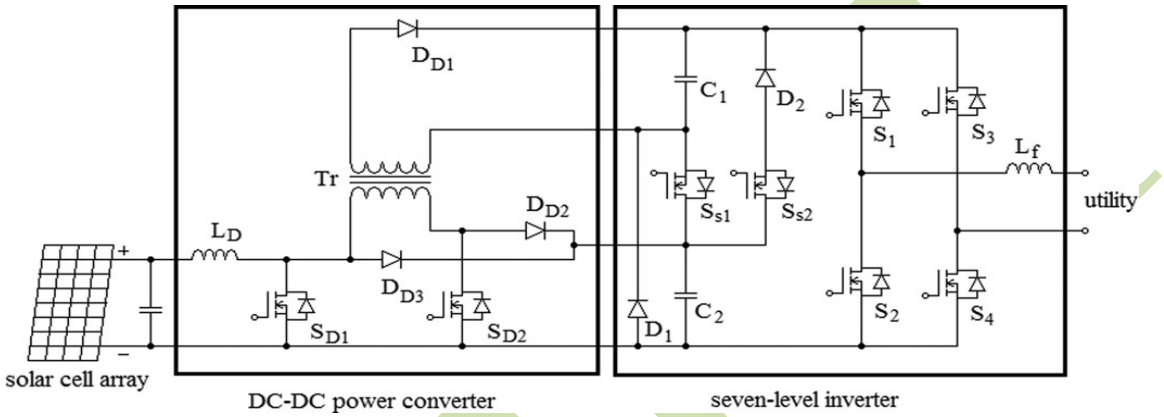


**Figure 1: Configuration of the proposed solar power generation systems.**

This work proposes a system with solar array, DC-DC power converter and seven-level inverter. The seven-level inverter is configured using a capacitor selection circuit and a full-bridge power converter, connected in cascade.

## LITERATURE REVIEW

**Jun Mei** has proposed multilevel inverter with phase disposition pulse width modulation (PDPWM). This system can be applied for photovoltaic grid connections. In this method, extra compensation signal was not used as it is based on selective virtual loop mapping to achieve dynamic capacitor voltage balance. The balance in the voltages of upper/lower arms capacitors is achieved by changing the loop mapping relationship between the virtual sub module and real sub module.MIN and MAX capacitor voltage index makes it suitable for multilevel converter. With this arrangement large number of sub modules can be used in one arm. Realization of this method is easily possible in the field of programmable gate array. This method provides better regulation and control. Author has carried out the experimental analysis of this scheme by means of simulation module [1].

**J. Dionisio Barros** has focused on the implementation of new digital control methods for neutral point clamped (NPC) multilevel converter by use of microprocessors. In this paper author has implemented a new control method called "fast predictive." Present predictive methods needs 27 calculations while the proposed method uses model equations just once in each control cycle. In the implemented method the speed of digital processing of the multilevel inverter is increased by 150% than predictive normal control. Due to improved speed, multilevel inverters can use five or higher number of levels (125 instead of 27 vectors)

to be controlled using the same sampling frequency of the three-level inverter. The results of the experiment carried out shows that the system is able to control the ac currents of a three-phase multilevel rectifier, achieving nearly 1.5% total harmonic distortion while balancing the capacitors dc voltages. The use of predictive control to regulate the dc voltage shows an improvement of approximately 7% compared to a proportional-integral controller [2].

**I. Abdalla** has addressed the problem of partial shading of individual photovoltaic sources connected in series. The new method developed i.e. "PV permutation algorithm," for extracting the maximum power from each PV cell. It is based on the PWM, the sequential permutation PV sources, and the output generation to control the multilevel dc-link inverter. Author has successfully applied this method to a seven level inverter with power tracking algorithm and the results were presented in the paper [3].

**Javier Chavarría** has implemented the energy balanced control for cascaded single phase grid connected H- bridge inverter. Here the control scheme uses an energy-sampled data model of the PV system. It provides voltage loop linear controller for each array. The system is operating on lower switching frequency in order to reduce the switching losses, of the seven- level inverter [4].

**Youssef Ounejjar** has implemented the new six band hysteresis technique for efficient control in the seven-level packed U cells converter (PUC). It provides the advantages of both i.e. flying capacitor and the cascaded H-bridge methods. It can be implemented in inverter as well as converter mode. Reduction of filter ratings is possible due to low harmonic contents. Hence reduction in installation cost and high efficiency with improved performance is achieved. The experimental implementation using real-time controller, the DS1103 of dSpace is presented in paper [5].

**Xu She** has presented the novel approach of voltage control for cascaded multilevel converter. The system provides the elimination of coupling between voltage-balancing controller and the original system controller. Author has carried out and presented this research work by considering the design details. This paper explores that the voltage imbalance in the soft-start process caused by an unsuitable reference, and presents a simple modified reference generation solution. Finally, both simulation and experimental results verify the performance of the proposed control system [6].

**Kazunori Hasegawa** has implemented five-level diode-clamped pulse width-modulated (PWM) inverter. This can be implemented for the constant torque motor drives like drilling rigs, extruders, and rubber mixers. The conversion of power is achieved by diode rectifier, PWM inverter and dc voltage balancing circuit with inductor. Due to addition of voltage balancing circuit it is possible to reduce harmonics and control in amplitude of magnetic flux produced by coupled inductor. Authors have performed an experiment of 200 V, 5.5 kW, model and found that the peak value of magnetic flux was not exceeded its designed value. The software package of the "PSCAD/EMTDC" was used for model implementation. Authors have finally concluded that that the power loss of IGBT module with presence of $9^{th}$ harmonic zero sequence voltage injection is reduced to 78% [7].

**Sanghun Choi** has proposed the multilevel flying capacitor converter (FCC) model with closed loop voltage balance.SVM method has benefits over other systems. Authors have studies and implemented the grid performance with four-level FCC under various operating

conditions with PSCAD/EMTDC environment to reduce the cost. The scheme has regulated the capacitor voltages at their nominal reference values [8].

**Edris Pouresmaeil** has implemented the control scheme for connection of distributed generation to grid for renewable sources. The scheme implemented generates the compensation current. This reference current can be used for distributed generation control loop. Various linear and nonlinear loads are supplied by DG link. By implementation of the proposed scheme authors have achieved improvement in power factor by reduction in harmonic distortion. Active and reactive power of the load is also compensated by the proposed scheme. The scheme is useful for integration of renewable energy resources to the AC grid [9].

**Rosa A. Mastromauro** has proposed the integration of photovoltaic system for residential buildings. The proposed scheme has addressed the problems in such integration for better efficiency and low harmonic distortion. MTTP, Current and voltage control, and implementation of digital signal processor are reviewed and discussed in this paper [10].

**Steven Thielemans** has presented the FCC voltage balancing mechanism. Authors have implemented the PS-PWM scheme for a single-leg five-level FCC with modifications. From the experimental study authors have concluded that, when this scheme is implemented for voltage balance, the balancing problems are solved [11].

**Jia-Min Shen** has proposed the new scheme of transformer less grid connected photovoltaic system. The corrosion occurred in grid connected solar cell array can be avoided by connecting the negative terminal of array to ground. Converter and inverters are used for power conversion. At a time only any two switches are operating. By this scheme the leakage current of the solar arrays was reduced. It improves the system efficiency as it works on maximum power tracking technique [12].

**Zheng Zhao** has implemented the transformer less grid connection concept to the single phase system for residential applications. The inverter used is implemented with boost and buck converters. The only operating switch with high frequency gives improved efficiency. Power MOSFET's and ultra fast recovery diodes can be used for this scheme. In this paper authors have analysed boost-buck converter based inverter theoretically. Authors have implemented the module and carried out the simulation based study and achieved 98.5% efficiency up to 1 KW power condition [13].

**Laxman Maharjan** has discussed about the battery energy storage system based on multilevel inverters. The PWM scheme is also applied for control. Authors have implemented the active power control scheme for 200-V, 10-kW, 3.6-kWh battery energy storage system effectively as active power plays a vital role in performance of battery. [14].

**Javier Pereda** has addressed the problems of Asymmetric Cascaded H-bridge multilevel inverter for the application of battery driven vehicles by using high frequency link with one power source. Authors have presented the experimental results of 27-level ACHB inverter with a variable and single dc source. This scheme can be implemented to any ACHB. By implementation of this scheme low harmonic distortion is achieved [15].

## CONCLUSION

The proposed solar power generation system uses solar cell array, dc-dc power converter and seven-level inverter. Converter boost output power of solar cell array and make two voltage levels with help of capacitors C1 and C2. New seven-level inverter uses only six power electronic switches reducing complexity. Only one power electronic switch is switched at high frequency to generate the seven-level output voltage. This reduces power loss and improves the power efficiency. Study of all papers states that proposed solar power generation system generates a seven-level output voltage and outputs a sinusoidal current that is in phase with the utility voltage which leads to unity power factor. As MPPT is also used in proposed system maximum power can be traced by solar array.

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