# Design of a Multi-Level Inverter with less Switches for Micro-Grids

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**ABSTRACT-** This work presents a single-phase multilevel inverter topology with fewer switching components that is driven by unconventional energy sources. Due to the numerous advantages, it offers over two-level inverters, multilevel inverter technology has lately grown in popularity in the industrial sector for applications demanding medium and high voltages. These benefits include the ability to produce high-quality output voltage with low switching frequency and low harmonic distortion. This popularity is growing daily. In this project the presentation of a novel system design for a grid-connected hybrid solar and wind energy system. The total Harmonic Distortion THD of the output voltage is reduced. when a five-level inverter is used, and this helps to eliminate the need for bulk filters on the output side.

**Key words-** Hybrid system, Wind, THD, PV, MLI, Inverter

## I. INTRODUCTION

Increasing the amount of power generated by renewable energy sources is required in order to reduce dependency on fossil fuels and bring down emissions of greenhouse gases [1]. This can be done mostly by using wind and solar power, however owing to the nature of these RESs, there are a number of management issues with managing electric networks [2]. Actually, they have the same characteristics, including extremely fluctuating rates and inadequately predicted energy output profiles. Therefore, RES generation must be limited, which lowers RES penetration levels than expected. The electric system is unable to handle these intermittent power sources beyond a certain point. For grid-connected photovoltaic applications, a unique power conversion scheme is proposed in [3]. Based on a multilevel inverter, the fossil fuels are so dependent on them and are getting more and more expensive, other energy sources have been proposed and created. Fossil fuels, on the other hand, have a significant detrimental influence on the environment. The term "new energy sources" in this context primarily refers to renewable energy sources. The production of electrical energy from renewable sources is projected to increase. Typically, the complimentary nature of solar and wind energy is recognised. Thus, compared to each of them functioning separately in [4], the hybrid energy system photovoltaic and wind energy is more reliable to provide continuous electricity.

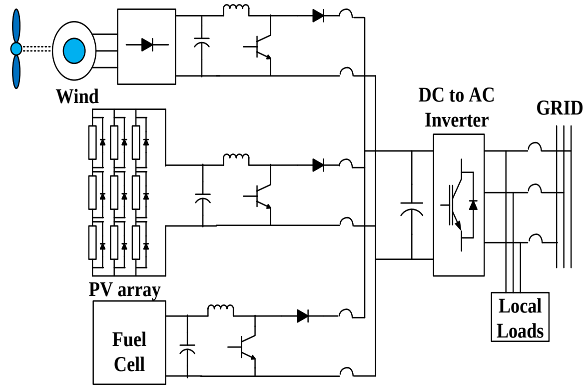


Fig.1: Hybrid generation system

Another benefit of the hybrid system over independent operation is the potential reduction in battery storage capacity. A DC/DC power converter is the initial piece of equipment, and its job is to make sure that the PV arrays can function as efficiently as possible. A DC/AC power converter is necessary to connect the solar power system to the public electrical grid. Reduced power ratings of the power devices and lower power device costs are two of the system's most significant gains when a multilayer inverter architecture is used [5]. A multilevel converter's primary purpose is to raise operating voltage by interconnecting power semiconductors in series switches for semiconductor power devices with far lower power ratings than those present in a normal pair of inverters [6]. By controlling these power switches, various dc sources can be used to produce a wider range of voltage levels at the output. One of the best characteristics of a multilayer inverter is its capacity to function at a wide range of switching frequencies, from the fundamental frequency to exceptionally high frequencies. The 5-Level & 11-Level Multilevel Inverter Fed Load Using PV Source project shows the results and provides the Matlab/Simulink platform.

## II. EFFECTIVE PRINCIPLES

Fig. 2 shows the block diagram of the proposed architecture. The input voltage needs to remain constant for the battery to charge efficiently. Therefore, by feeding the solar panel output through a boost converter, the output voltage of the solar panel is kept constant at 12V. In this situation, the wind generator is a 230V DC shunt generator. A buck converter is used to increase the wind generator's output voltage to 12V. As a result, the battery will be charged by the sun and wind. By feeding it through a 5-level multilevel inverter, the battery's output is converted into ac.

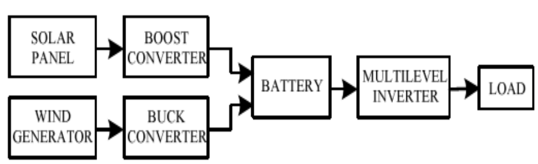


Fig.2.Block diagram of proposed architecture

PV (photovoltaic) systems are used to convert solar energy directly into electrical energy. The main element of a PV system is a PV cell. Structures built of cell groupings are called arrays. Smaller loads, including lighting systems and DC motors, can be powered by the voltage and current that are already present at the terminals of a solar device. Alternatively, the voltage and current can be linked to the grid using the required energy conversion equipment

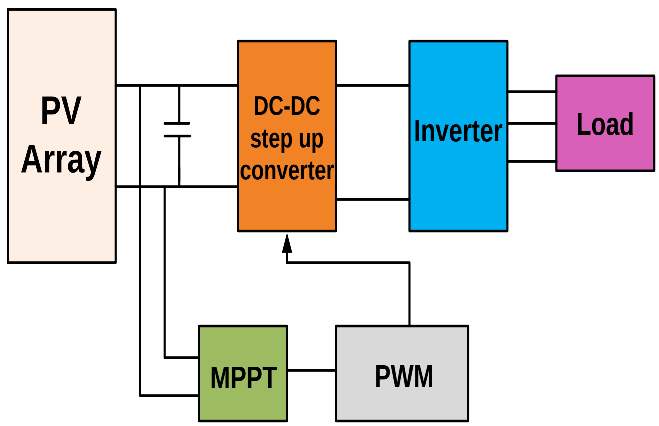


Fig.3. Block diagram representation of Photovoltaic system

The three crucial parts of this solar system are the load, the system balance, and the PV module. This system's MPPT, batteries, and other components make up the majority of the balancing components. Fig. 3 shows a block diagram of the PV system. A p-n junction is a solar cell's main structural element. Photovoltaic cells are made from a range of semiconductor types using a variety of manufacturing processes. Charge carriers are produced when light enters a cell. These charge carriers begin an electric current if the cell shorts out.

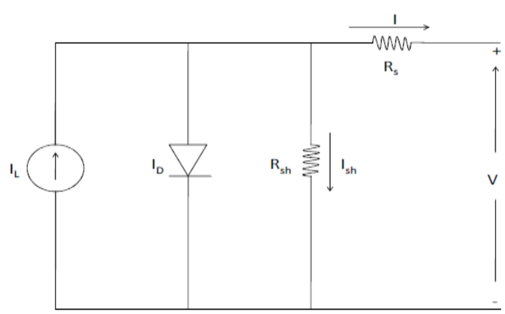


Fig.4. Practical PV device

The equivalent circuit for a photovoltaic cell is shown in Figure 4. The series resistance, RS, or resistive shunt represents the internal losses caused by the current flow. When a diode is linked in parallel, Rsh represents the leakage current to the ground. The physics of the PN junction served as the basis for this equation. The integration of RES applications powered by solar systems into the grid is quickly overtaking traditional stand-alone systems as the most popular application for PV systems. This trend is escalating since implementing RES in distributed (also known as dispersed, embedded, or decentralised) generation (DG) power systems offers so many benefits. There are several reasons why we should switch to renewable energy, in addition to the depletion of fossil resources. Pollution is beginning to pose a serious problem in many countries, especially those that are developing. Due to the highest amounts of carbon emissions, which can cause cancer and respiratory diseases, some areas can have relatively bad air quality. The main argument in favour of moving to more environmentally friendly energy producing methods is the threat posed by global warming. The impact grows as we emit more carbon dioxide into the atmosphere. We cannot simply stop using fossil fuels in the hopes that global warming would stop, but we may delay its advancement and mitigate its effects by using them widely.

## III. CONVERTER TOPOLOGY

There are various PV system configurations. Examples of these arrangements are the centralised, string, multi-string, and AC-module configurations. A PV system's ability to connect to the grid may need a specific number and kind of power converters, depending on the technology being used. The multi-string technique divides PV arrays into multiple different groups. Each group is sequentially connected to a DC/DC converter. This method can therefore be applied to some switching devices, such as pipelined multi-cell generators. To create this topology, a series connection is made between one-phase inverters using various DC sources. This makes it possible to use each group of PV arrays as a separate DC source. Significant voltage amplification can be prevented as a result [7].

### A. DC/DC CONVERTER

In this setup, we employ two distinct types of DC-DC converters to reduce the direct current (dc) voltage produced by the wind energy system and solar photovoltaic system to a level suitable with the battery. A boost converter is utilised so that the voltage of the solar photovoltaic system may be brought up to the level of the battery voltage. Using buck converters, the voltage of the wind energy system is decreased until it is equivalent to the voltage of the batteries.

### B. MULTILEVEL INVERTERS

The old design has been modified by this one. Figure 5 depicts the circuit's configuration. A voltage of equal to Vdc/2 can damage any DC capacitor. The proposed inverter's operation depends on the production of five different output voltage levels, which are designated as Vdc, Vdc/2, 0, -Vdc/2, and -Vdc.

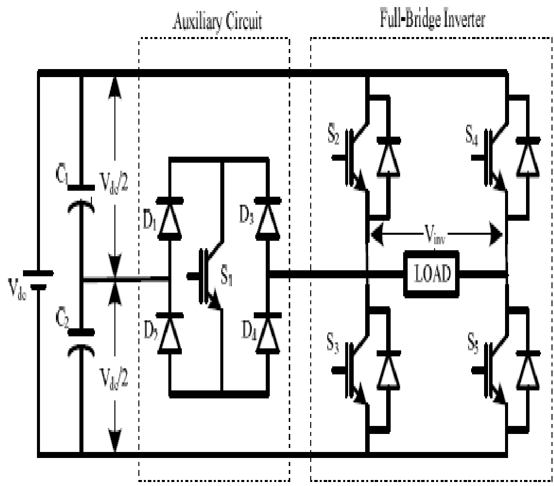

Fig.5 Representation of a 5-level inverter

## IV RESULTS AND DISCUSSION

Simulation results are performed for the two main objectives for a single phase power system network.
1) Design a 5-Level MLI topology for PV Application and its switching sequence.
2) Design a 11-level MLI topology for PV Application and its switching sequence.

*Case 1: RES interconnected proposed 5-Level MLI Topology*

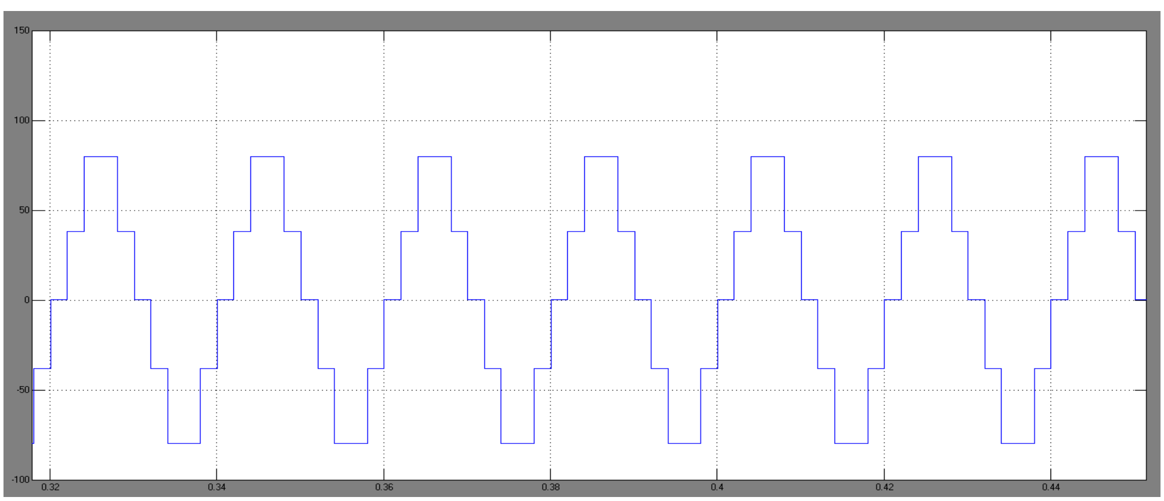
Fig.6 Output Voltage of Proposed 5 Level MLI

Fig.6 depicts the output voltage of proposed 5-Level MLI Topology.

*Case 2: PV interconnected to proposed 11-Level MLI configuration*

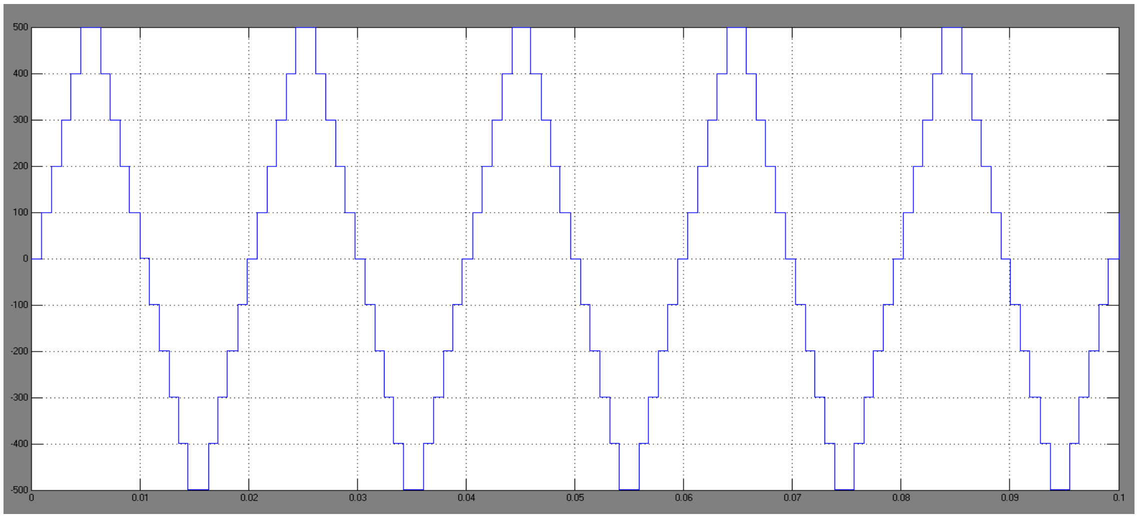


Fig.7 Output Voltage of Planned 11Level MLI

Fig.7 Level Output Voltage of Proposed Inverter Topology with PV Source.

## V.CONCLUSION

This inquiry models and simulates a single phase 11 level inverter powered by a PV source and equipped with a cutting-edge multilayer inverter. The suggested remedy lowers voltage THD while including a PV energy system. The suggested 5 & 11 level inverter design uses fewer switches and an input DC Source than the typical cascade H-Bridge configurations. Although there are fewer switching devices as a result, the cost and complexity of the control are reduced. Additionally, switching losses are decreased, which tends to increase the converter's overall efficiency and reliability.

## REFERENCES

[1] S. Mishra and A. N. Tiwari, "Simulation and Analysis of Open Loop PV system with Double Stage Conversion," 2020 Int. Conf. Comput. Perform. Eval. ComPE 2020, pp. 491–496, 2020, doi: 10.1109/ComPE49325.2020.9200104

[2] IEEE Power and Energy Society, "IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems IEEE Power and Energy Society," vol. 2014, 2014. doi: 10.1109/IEEESTD.2014.6826459.

[3] M. Morales-Caporal, J. Rangel-Magdaleno, H. Peregrina-Barreto, and R. Morales-Caporal, "FPGA-in-the-loop simulation of a grid-connected photovoltaic system by using a predictive control," Electr. Eng., vol. 100, no. 3, pp. 1327–1337, Sep. 2018.

[4] J. Rodríguez, J. S. Lai, and F. Z. Peng, ―Multilevel inverters: A survey of topologies, controls, and applications, *IEEE Trans. Ind. Electron.*, vol. 49, no. 4, pp. 724–738, Aug. 2002

[5] Holmes, D.G, McGrath, B.P. "Multicarrier PWM strategies for multilevel inverters" Industrial Electronics, IEEE Transactions, Vol. 49, issue:4, pp.858- 867,Aug 2002.

[6] K.K. Gupta, A. Ranjan, P. Bhatnagar, L. K. Sahu and S. Jain, "Multilevel Inverter Topologies With Reduced Device Count: A Review," in IEEE Transactions on Power-eletronics,vol. 31, no. 1, pp. 135-151, Jan. 2016

[7] Zulkifile, Md Liton, "A Five level cascaded H-bridge inverter based on space vector pulse width modulation technique", IEEE Transactions on Industrial Electronics, Page(s):293-297,2014.

[8] S. Mekhilef, M. Abdel Naeim, A. Masaoud, and H. Belkamel, "Novel three-phase asymmetrical cascaded multilevel voltage source inverter," IET Power Electron., vol. 6, no. 8, pp. 1696–1706, Sep. 2013.

[9] H. R. Massrur, T. Niknam, M. Mardaneh, and A. H. Rajaei, "Harmonic Elimination in Multilevel Inverters Under Unbalanced Voltages and Switching Deviation Using a New Stochastic Strategy," IEEE Trans. Ind. Informatics, vol. 12, no. 2, pp. 716–725, Apr. 2016.