



# “FIVE-STAGE, SINGLE-SOURCE MULTILEVEL INVERTER FOR GRID-CONNECTED PHOTOVOLTAIC SYSTEMS”

GUNASEKARAN.N<sup>1</sup>, ARULKUMAR.C<sup>2</sup>

PG student, Department of EEE, Paavai Engineering College, Namakkal, Tamil Nadu, India<sup>1</sup>

Asso Professor, Department of EEE, Paavai Engineering College, Namakkal, Tamil Nadu, India<sup>2</sup>

**Abstract:** When compared to two-stage converters, this five-stage converter helps the inverter handle almost twice as much power. Design issues with power conditioning units for grid-connected solar photovoltaic systems include power quality, efficiency, dependability, implementation costs, etc. In order to solve the majority of the practical limitations of central DC source application, this article discusses a single DC-source-based five-level-doubling network high-resolution multilevel inverter topology with the right combination of switches. To boost efficiency and double inverter utilization, a five-stage high-resolution multilevel inverter solution is modified. This work also demonstrates the system's ability to handle reactive power and block faults. MATLAB/Simulink is used to extensively simulate the converter. The proposed concepts' effectiveness is confirmed by the laboratory prototype's experimental findings. A common PV array powers the main bridge, while separate sources power the auxiliary bridges. Even though these separated sources need far less electricity, The overall cost of the system reflects it. A low-gain PI controller has been used to eliminate these isolated sources. The dc source in this converter only feeds the main bridge. With the aid of transformers, all major bridges for grid-connected solar PV applications are combined and fed by a single PV array. During unbalancing, there won't be any mismatch because three DC buses are combined. As a result, the system will not stray from MPPT and will continue to provide power quality. Between the PV and the inverter, there is a boost converter. When compared to single-stage converters, this two-stage converter enables the inverter handle almost twice as much power.

## 1.1 INTRODUCTION

A sophisticated power electronics device called a five-stage multilevel inverter is used to transform direct current (DC) power into higher voltage alternating current (AC) power. Addressing the increasing need for dependable and efficient energy conversion systems in a variety of applications, including motor drives, grid-connected systems, and the integration of renewable energy sources, is the main goal of the research and development of these inverters. The goal of this technique is to get beyond the drawbacks of conventional two-level inverters, which include increased output waveform harmonic distortion and higher voltage stress on semiconductor components. Enhancing system performance and efficiency is a major goal of research on five-stage multilevel inverters. These inverters can produce a cleaner, more sinusoidal AC output by reducing the overall harmonic distortion by employing various voltage levels in the output waveform. This is critical for uses like sensitive electronic equipment and industrial processes where high-quality electricity is required. Reduced harmonic distortion eventually improves the power conversion system's reliability by improving power factor and lessening the strain on linked devices. Improving the inverter design's modularity and scalability is another goal. By design, multilevel inverters have a modular framework that is readily expandable by incorporating more levels into the system. Because of its scalability, the inverter can be easily adjusted to meet varying power and voltage needs, which makes it appropriate for a variety of uses. In order to maximize the effectiveness of each step and guarantee the smooth integration of subsequent stages without sacrificing the overall efficiency of the system, researchers are working to create novel control strategies and modulation techniques. Additionally, investigating the possibilities of five-stage multilevel inverters within the framework of renewable energy systems is the goal.



## 1.1 LITERATURE REVIEW

### Stage Multilevel Inverter:

An advanced power electronics device utilized in electric vehicles, renewable energy systems, and high-voltage power transmission is the two-stage multilevel inverter. Comparing this inverter topology to typical inverters, there are benefits including increased efficiency, decreased harmonic distortion, and better output waveform quality since it uses numerous power semiconductor devices to create an output voltage waveform with many levels. A voltage waveform resembling a staircase is produced in the first stage of a two-stage multilevel inverter by connecting many lower-voltage DC sources in series. Batteries, capacitors, and other energy-storing components are examples of these sources. The inverter can manipulate various DC sources to produce a multilevel AC output voltage by managing the switching of semiconductor devices, such as metal-oxide-semiconductor field-effect transistors (MOSFETs) or insulated gate bipolar transistors (IGBTs). The staircase voltage waveform is converted into a superior sinusoidal output voltage in the second stage of the inverter.

## 2. EXISTING SYSTEM

To effectively convert and manage electricity in renewable energy applications, the two-stage multilevel inverter system integrates a number of essential components. Utilizing electricity from a photovoltaic (PV) source is the first step. The two-stage system's main input is direct current (DC) electricity produced by photovoltaic panels using sunshine. In order to maximize power extraction, the voltage levels between the PV array and the system's subsequent stages are regulated and matched by a DC-DC converter. Maximum Power Point Tracking (MPPT) algorithms are essential for ensuring that the PV system runs as efficiently as possible, especially when used in conjunction with the DC-DC converter. Optimal energy harvesting is ensured by MPPT controllers, which dynamically modify the PV array's operating point to maximize power output under variable environmental circumstances. The multilevel H-bridge inverter, a crucial part in producing a high-quality alternating current (AC) waveform from the DC output, is a part of the two-stage multilevel inverter's second stage. Multiple H-bridge modules, each able to produce a different voltage level, make up this inverter structure.

## 3. PROPOSED SYSTEM

The suggested system is a grid-connected solar photovoltaic (PV) system that uses a single-sourced, five-stage multilevel inverter. The goal of this novel inverter architecture is to improve grid-tied solar PV projects' dependability and efficiency. Increased voltage levels are made possible by the five-stage arrangement, which enhances power quality and lowers total harmonic distortion (THD) in the output waveform.

### 3.1 Objectives

A complex power electronics device intended for grid-connected solar PV systems is the single-sourced five-stage multilevel inverter. The purpose of this inverter arrangement is to improve the dependability and efficiency of solar power conversion. Better harmonic performance and more control over the output waveform are made possible by its five-stage design. This is especially helpful for grid-connected systems, where a smooth integration with the utility grid depends on maintaining high-quality electricity. Optimizing energy conversion and grid interaction is the main goal of using a single-sourced, five-stage multilevel inverter in grid-connected photovoltaic systems. Finer voltage resolution is made possible by the multilevel construction, which also lowers total harmonic distortion (THD) and enhances power quality overall. Additionally, the system is streamlined by the single-sourced design, which reduces complexity and increases efficiency. With constant environmental adjustments, the inverter's sophisticated management algorithms enable effective Maximum Power Point Tracking (MPPT) for the solar panels, guaranteeing that the system runs as efficiently as possible.



### 3.2 Block Diagram

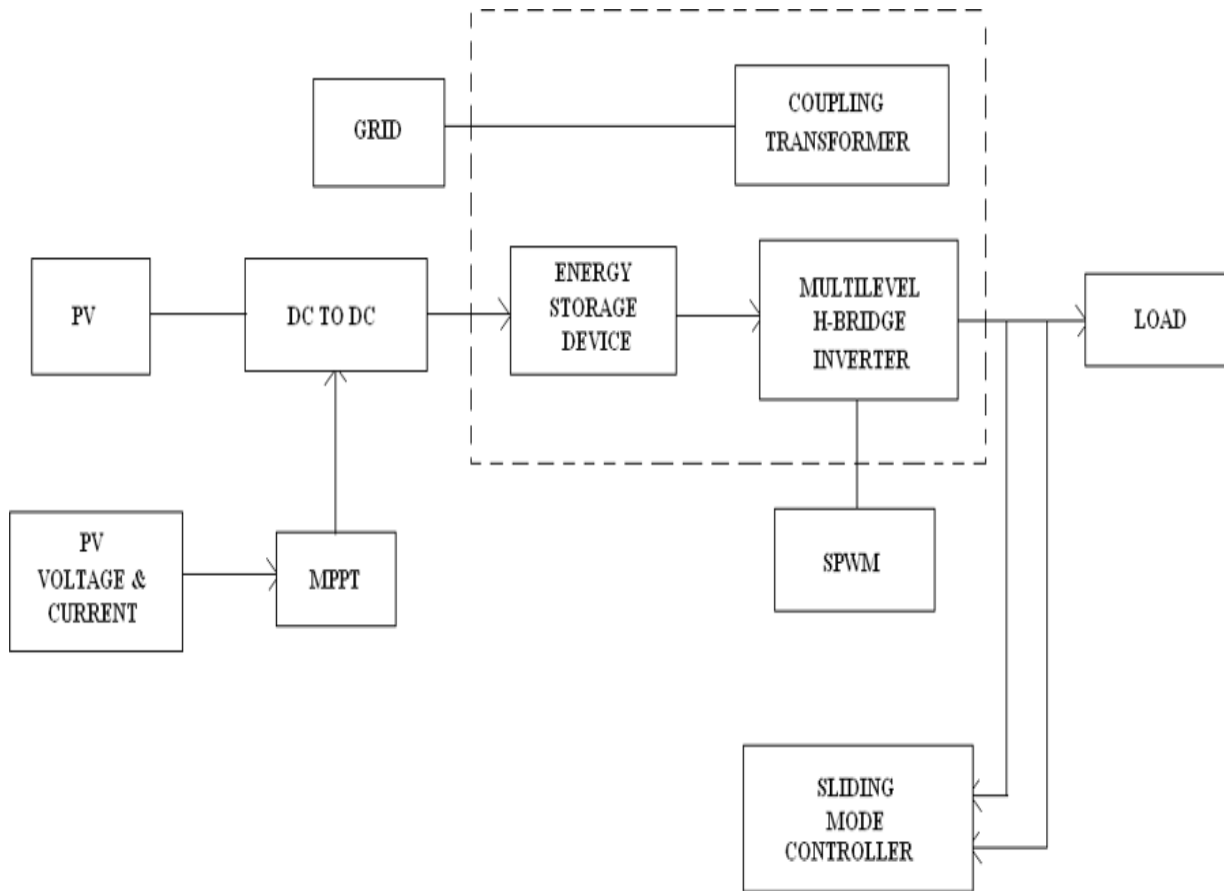


Fig 3.1 Block Diagram for Proposed Method

### 3.3 Block Diagram Explanation

#### Grid:

The network that transports electricity from power plants to end users is known as the electrical grid. When solar power output is insufficient, the grid is frequently employed in solar power systems to import power or export excess electricity. The grid connection is an essential part of a five-stage multilevel inverter system that affects the overall operation and efficiency of the power conversion process. Facilitating the multilevel inverter system's integration into the current electrical grid infrastructure is the main goal of the grid connection. With the help of this link, the inverter may inject the generated AC power into the grid, facilitating the integration of renewable energy sources into the larger power distribution network. Adherence to pertinent grid norms and standards is necessary for the grid connection to guarantee the smooth.

#### Coupling Transformer:

A coupling transformer can be employed in certain solar power systems to effectively transfer power by matching the voltage levels between the grid and the solar array. The coupling transformer plays a crucial role in enabling the connection between the inverter and the electrical grid in a five-stage multilevel inverter system. In order to ensure a smooth and effective energy exchange, the coupling transformer is essential in matching the voltage levels between the multilevel inverter and the grid. The voltage at the inverter side can be suitably stepped up or down to match the grid voltage needs by modifying the transformer's turns ratio. In order to minimize grid disruptions, improve grid compatibility, and maximize power transfer between the five-stage multilevel inverter system, through this isolation, the inverter system is shielded from potential grid faults and disruptions, guaranteeing dependable and safe operation. Furthermore, the coupling transformer contributes to the overall power quality of the 5-stage multilevel inverter system by reducing the



effects of harmonics and transients. As a result, the coupling transformer plays a crucial role in the 5-stage multilevel inverter's interface, guaranteeing safe and effective integration with the power grid and improving system stability.

#### **PV (Photovoltaic) System:**

Solar panels, which are part of the PV system, transform sunlight into electrical energy. Electricity with direct current (DC) is produced by these panels. As the main source of renewable energy in a 5-stage multilevel inverter system, the photovoltaic (PV) component is essential. The PV system, which consists of solar panels that transform sunlight into direct current (DC) electricity, is the cornerstone of the entire power generation process. The unique characteristic of the five-stage arrangement is its capacity to effectively capture solar energy through the incorporation of several voltage levels. Through the photovoltaic effect, which occurs when sunlight excite electrons in semiconductor material to create an electric current, solar panels produce DC electricity. The PV array's DC output is optimized by the 5-stage multilevel inverter system, guaranteeing a steady and high-quality input.

#### **DC-DC Converter:**

To maximize the solar panels' power production, a DC-DC converter is employed. It has the ability to modify voltage levels to meet grid or downstream component requirements. The DC-DC converter is an essential bridge in a five-stage multilevel inverter system that facilitates effective energy transmission from the photovoltaic (PV) array to the successive multilevel inverter stages. The DC-DC converter is essential in controlling and changing the voltage output from the PV system to meet the demands of the multilevel inverter, which has five different voltage levels. This converter makes sure that the inverter obtains a steady and optimal DC input for power conversion by controlling the dynamic variations in solar irradiance and environmental factors. Different topologies, such buck, boost, or buck-boost converters, might be used depending on what the 5-stage multilevel inverter system needs. By reducing power losses during the energy transfer from the PV array to the inverter, the DC-DC converter improves the overall efficiency of the energy conversion process. Stable and dependable power output is facilitated by its capacity to match the voltage levels between the PV system and the multilayer inverter. Furthermore, sophisticated control algorithms are put into practice to manage the DC-DC converter's functioning and enhance its performance under various load scenarios. In conclusion, the DC-DC converter plays a critical role in the 5-stage multilevel inverter system, which makes it easier to integrate renewable energy sources into the power grid effectively and smoothly.

#### **Energy Storage Device:**

Batteries and other energy-storage devices are used to store extra energy produced by photovoltaic systems during sunny spells. You can use this stored energy when there isn't as much sunlight or when demand is strong. Integrating an Energy Storage Device (ESD) into a 5-stage multilevel inverter system is essential to improving the overall performance and flexibility of the power conversion process. During times of high generation, the energy storage device (ESD), which is often composed of batteries or other energy storage technologies, acts as a buffer to store extra energy. With the inverter having five voltage levels, the ESD plays a crucial role in maintaining a steady power production by skillfully controlling variations in the renewable energy sources. To ensure a steady and dependable power supply, the energy stored in the ESD can be released during times of low generation or high demand. Additionally, the 5-stage multilevel inverter system's ESD provides ancillary services such peak shaving, load leveling, and frequency regulation, which serve grid support functions. The inverter plays a more crucial role in grid stability and dependability when it has the capacity to store and release energy wisely. The ESD's charging and discharging cycles are regulated by sophisticated control algorithms, which maximize energy efficiency and increase the system's overall robustness.

#### **Load:**

The appliances or electrical equipment that use the solar system's power are referred to as the load. Appliances, lighting, and other electrical devices may fall under this category. The electrical or electronic equipment that uses the AC power produced by the inverter is referred to as the load in a five-stage multilevel inverter system. Applications for the load can be wide-ranging, ranging from industrial gear to home and commercial appliances. With five voltage settings, the inverter's output produces a high-quality AC waveform that can power a range of loads. To



ensure dependable and effective functioning, the inverter must be built to satisfy the unique specifications and standards connected to the connected devices. The choice of load is also very important. The 5-stage multilevel inverter system's design and control tactics are influenced by the characteristics of the load and its power requirements. For the inverter to keep the power supply steady, it must adjust to changing load conditions. In order to guarantee that the inverter system reacts dynamically to variations in load demand and produces reliable, high-quality power output, advanced control algorithms are frequently used. The multilevel inverter's integration into the overall electrical system highlights how crucial it is to comprehend and meet the needs of the load, as this will ultimately determine the inverter's efficacy and capacity to support a dependable and effective power distribution network.

#### **MPPT (Maximum Power Point Tracking):**

The MPPT control algorithm continuously modifies the solar panels' operating point in response to external factors, maximizing the PV system's power output. Maximum Power Point Tracking (MPPT) is a crucial component in a 5-stage multilevel inverter system for maximizing the efficiency of photovoltaic (PV) arrays. When the inverter has five different voltage levels, the MPPT algorithm is essential for dynamically modifying the PV system's operating point. Its main job is to make sure the PV array runs as efficiently as possible while taking temperature, shade, and sunlight fluctuations into account. To maximize the total efficiency of the 5-stage multilayer inverter and collect the maximum amount of energy from the PV system, real-time optimization is necessary. The 5-stage multilevel inverter system's MPPT capability is made possible by sophisticated algorithms that continuously assess the electrical properties of the PV system. MPPT lessens the effects of shifting climatic circumstances by dynamically adjusting the electrical operating point, guaranteeing that the PV array continuously provides the inverter with the best possible power.

#### **SPWM (Sinusoidal Pulse Width Modulation) Controller:**

When applied to an inverter, pulse width modulation (SPWM) is a modulation technique that creates a sinusoidal waveform. Controlling the power electronic device switching in inverters is a popular usage for it. The Sinusoidal Pulse Width Modulation (SPWM) Controller plays a crucial role in determining the output waveform of a 5-stage multilevel inverter system. By precisely manipulating the pulse widths to resemble a sinusoidal waveform, SPWM—a complex modulation technique—is used to regulate the switching of power semiconductor devices in each step of the inverter. The SPWM Controller plays a crucial role in producing a high-quality AC output with lower harmonic distortion since it can control five different voltage levels. Performance that is consistent and dependable is ensured by the controller's flexibility in responding to changing load situations and grid requirements. The SPWM Controller is an essential technology in the 5-stage multilevel inverter system for attaining high-performance AC power generation from renewable energy sources because it improves the inverter's overall efficiency and power quality.

#### **Sliding Mode Controller:**

A sliding mode controller is a kind of control system that works to assure a desired response by generating a sliding surface to help regulate the output of the solar inverter or other components. Every part of a solar power system, from gathering sunlight and turning it into electricity to effectively managing and distributing the generated power, has a distinct duty in the overall operation of the system. Sliding Mode Controller (SMC) use becomes more and more important in a 5-stage multilevel inverter system to achieve accurate and reliable power conversion process control. Utilizing a complex control technique, the SMC maintains stability and optimal performance under a range of operating situations by controlling the power flow between the electrical grid and the inverter system.

## **4.CONCLUSION**

In conclusion, the creation and application of the 5-stage multilevel inverter present a viable way to address the issues surrounding voltage control and power conversion in medium voltage sources. Through the resolution of conventional inverter constraints and an emphasis on efficiency maximization at the expense of voltage fluctuations, this technology creates opportunities for more dependable and efficient power delivery to delicate loads. Its relevance lies in its capacity to optimize the exploitation of renewable energy sources in many applications, such as solar panels, batteries, and supercapacitors, while also permitting increased output power. Going forward, the 5-stage multilevel inverter is a



reliable and scalable invention that is well-positioned to advance the integration of renewable energy into diverse electrical systems and stabilize power supply.

#### 4.1 Future Scope

The 5-stage multilevel inverter's potential for development offers an exciting path forward for advances in power electronics and integration of renewable energy sources. More investigation may be conducted to improve these inverters' modularity and scalability so that they can be tailored to a variety of power grid layouts. Investigating more sophisticated modulation methods and control schemes specifically designed for these inverters could maximize their effectiveness while lowering harmonic distortions and enhancing the quality of power transmission. Furthermore, exploring the incorporation of cutting-edge technology such as wide bandgap semiconductors or novel circuit topologies may improve the power density and dependability of these inverters. Furthermore, investigating hybrid setups that pair several renewable energy sources with 5-stage multilevel inverters appears to be a promising field, opening the door to more dependable, high-capacity energy conversion.

#### REFERENCES

- [1]. K. H. Ahmed, A. M. Ismail, M. A. S. Masoum, Development of a 5-Level Neutral Point Clamped (NPC) Inverter for Renewable Energy Applications.
- [2]. B. Singh, R. Kaur, Performance Analysis of 5-Level Multilevel Inverter for Renewable Energy Systems.
- [3]. R. K. Saini, S. K. Gautam, Five Level Multilevel Inverter for Renewable Energy Applications: A Review.
- [4]. Y. Liao, Y. Wu, Research on Control Strategy of Five-Level T-Type Inverter for Renewable Energy Systems.
- [5]. R. Choudhary, V. Jain, Design and Simulation of a 5-Level H-Bridge Multilevel Inverter for Photovoltaic Applications.
- [6]. P. N. Tekwani, S. J. Siddiqui, Performance Evaluation of 5-Level Inverter Topologies for Grid-Connected Renewable Energy Systems.
- [7]. S. Ezhilarasi, M. I. Raj, Analysis of 5-Level Inverter for Stand-Alone Wind Energy Conversion Systems.