Modeling and Simulation of PV based single phase seven level grid connected inverter system

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ABSTRACT

In the field of high-power medium-voltage energy regulation, multilevel inverters are a viable option. This project features cascaded multi-cells with independent DC sources. Multilevel inverters are promising since their output voltage waveform is virtually sinusoidal. For grid-connected solar systems, the standard is a single seven-level inverter with a new pulse width-modulated (PWM) control technique. Two H-bridge inverters with distinct dc sources were employed in this project. The proposed system's major goal is to reduce fluctuation, or if there are any louds, it requires a pure sinusoidal waveform. The industry creates and consumes that much space. Any device will work properly if it is utilised in a micro grid like this. In this proposal, a buck boost converter is used to manage photovoltaic power. The proposed system employs the MPPT technology to completely use the maximum amount of energy available from solar panels to the grid. Simulations in MATLAB/SIMULINK were used to verify the proposed system's performance.

Keyword: -. *Multilevel inverter, Pulse width Modulation, Modified H – Bridge Inverter, Renewable Energy, Bidirectional Switches,*

I. INTRODUCTION

Solar photovoltaic generation becomes more popular these days, and nonconventional energy source application are becoming more important. Because of unique advantages such as easy allocation, high dependability, high flexibility, cheap fuel cost, low maintenance, noiseless operation, and no wear and tear due to the lack of moving components. Solar energy also has the advantage of being a clean, pollution-free source of energy. Due to enhanced power electronic equipment and procedures, solar and wind facilities are among the most common types of renewable energy sources. Photovoltaic sources are employed in a variety of applications, including low- and medium-power applications.[1]

The PV with inverter converts Power supply from PV panels into AC power, which is then sent into the load.In recent years; multilayer inverters have piqued the interest of academics and industry for medium and high voltage applications. Because of its ability and high power applications, multilevel inverters have gotten greater attention. High power quality, lower order harmonics, smaller switching losses, and improved electromagnetic interference are all advantages of multilayer inverters. Using a number of input voltage sources as the input and an appropriate configuration of power semiconductor deviators, these multilevel generate a stepped inverter waveform.[2],[3]

The true objective of a multilayer inverter is to keep output waveforms close to sinusoidal and maintain power quality. The multilayer inverter not only achieves large power ratings, but it also allows renewable energy sources to be used. Photovoltaic, wind, and fuel cell energy sources may all be conveniently connected to a multilevel inverter system for high-power applications. Over the years, various topologies for multilayer inverters have been developed. like Diode-clamped [4–6], flying capacitor or multicell [7], cascaded H-bridge and modified H-bridge multilevel [8]

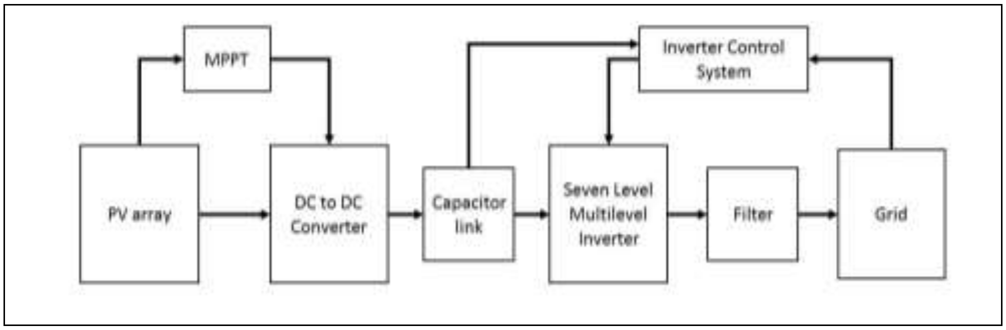

Fig-1 Block diagram of a single phase seven level inverter for grid connected photovoltaic system

Without such the usage of transformers, Multilevel inverters can achieve high voltages with little harmonic distortion. While the number of voltage levels rises, the harmonic content of the output voltage waveform falls dramatically. Multilevel inverters are more expensive because to the increased number of capacitors, clamping diodes, and DC sources required as the number of levels is increased. For medium and high power applications, a modified H-Bridge inverter is employed to overcome the difficulties mentioned above. Figure 1 shows a block schematic of a single phase seven-level inverter for grid-connected photovoltaics.

The construction of a modified single-phase multilevel inverter with two diode integrated bidirectional switches and a novel pulse width modulated (PWM) technology is described in this paper. With considerations for a maximum-power-point tracker (MPPT) and a current-control algorithm, the topology was applied to a grid-connected photovoltaic system.

II. PROPOSED MULTILEVEL INVERTER TOPOLOGY

The seven-level inverter in [7] has been used to develop the proposed single-phase seven-level inverter. As illustrated in Figure 2, it consists of a single-phase conventional H-bridge inverter, two bidirectional switches, and a capacitor voltage divider constituted by C1, C2, and C3.

For inverters of the same number of levels, the modified H-bridge architecture has substantial advantages over other topologies, such as fewer power switches, power diodes, and capacitors. A dc–dc boost converter was used to connect photovoltaic (PV) arrays to the inverter.

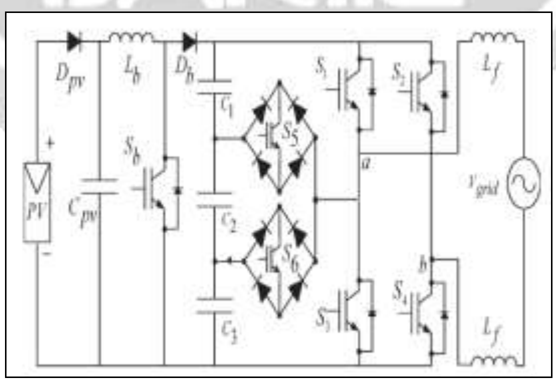

Fig-2 Proposed single-phase seven-level grid-connected inverter for photovoltaic systems.

The utility grid, instead of just a load, was employed to deliver the power produced by the inverter to the power network. Because the PV arrays' voltage was lower than the grid voltage, a dc–dc boost converter was necessary. To ensure that power flows from the PV arrays to the grid, high dc bus voltages are required. The current injected into the grid was filtered using a filtering inductance Lf. From the dc source voltage, the inverter may produce seven output voltage levels (Vdc, 2Vdc/3, Vdc/3, 0, -Vdc, -2Vdc/3, -Vdc/3) with proper switching. Output voltage for 7 levels of output voltage according to the switches' on–off condition is shown in the table below.

Table -1 OUTPUT VOLTAGE ACCORDING TO THE SWITCHES' ON–OFF CONDITION

v_0	S_1	S_2	S_3	S_4	S_5	S_6
V_{dc}	on	off	off	on	off	off
$2V_{dc}/3$	off	off	off	on	on	off
$V_{dc}/3$	off	off	off	on	off	on
0	off	off	on	on	off	off
0*	on	on	off	off	off	off
$-V_{dc}/3$	off	on	off	off	on	off
$-2V_{dc}/3$	off	on	off	off	off	on
$-V_{dc}$	off	on	on	off	off	off

III. Maximum Power Point Tracking PV algorithm

Under varying conditions, such as changing solar irradiance, temperature, and load, maximum power point tracking (MPPT) is an algorithm implemented in photovoltaic (PV) inverters to continuously adjust the impedance seen by the solar array to keep the PV system operating at, or close to, the peak power point of the PV panel.[9]

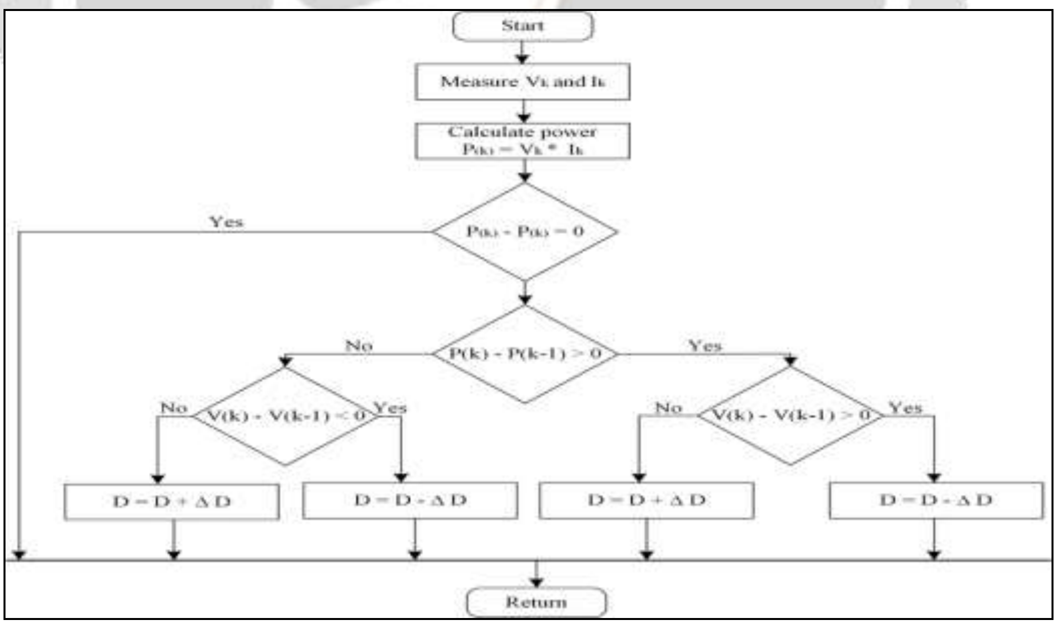

Fig-3 Flow chart of P & O algorithm

As the performance of the PV panel changes, the MPP shifts, and the ability to locate the MPP at any given time is critical. Recognizing the MPP allows the inverter to extract all of the power produced by the PV panel by drawing the proper voltage and current from it. The PV panel's efficiency is maximised when it is operated at the MPP. Because of the complicated link between the PV module's output current and voltage, determining where the MPP is located is difficult. The perturb-and-observe (P&O) maximum power point tracking approach is employed in this study shown in fig 3. The P & O method has a simple structure and only requires a few parameters. They work by periodically perturbing and incrementing or decrementing. The P&O algorithm works by increasing or decreasing the PV's output terminal voltage And P&O is a perturb-and-observe algorithm that compares the power obtained in the current cycle to the power obtained in the previous cycle.

IV. SIMULATION AND EXPERIMENTAL RESULTS

A. Proposed Simulation Model

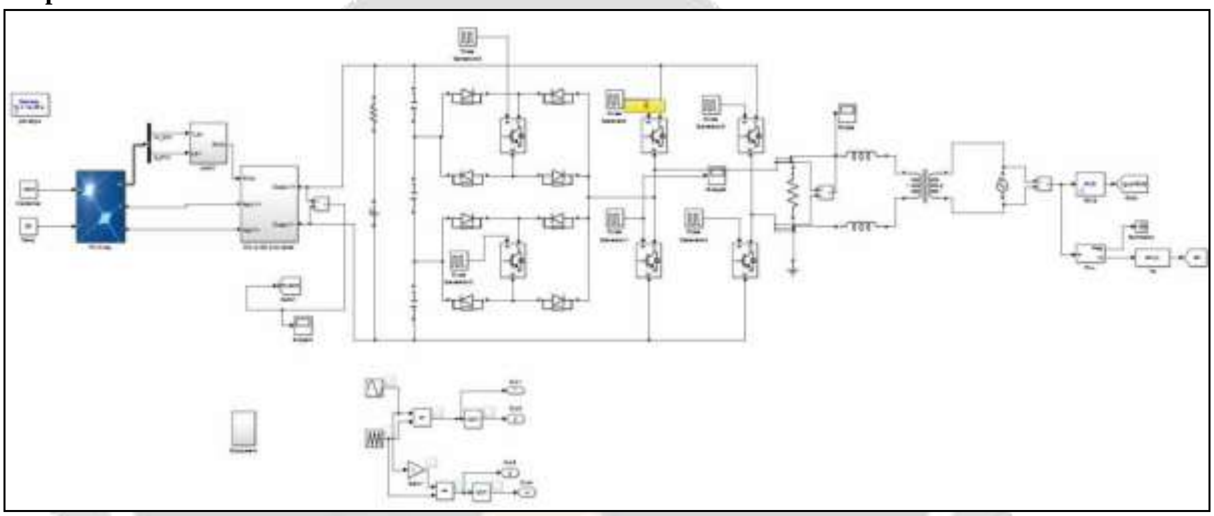

Fig -4 Proposed Simulink Model

The operation of a seven-level multilevel inverter required the use of a DC source. A VC source is required for a multilevel inverter. As a result, we continued to use a PV array or solar panel. The PV array will run on temperature, and the PV array's intensity input includes irradiance and temperature. The temperature on the PV plate will remain at 25°, and the irradiance will be 1000W/M2. On that plate, the same amount of radiation as 1000 will remain.[10]

A 1 converter is made up of a capacitor, inductor, diode, resistor, and one switch. The resistor controls the current while the capacitor stores DC charge. The charge is stored in the inductor. All of these charges boost the converter's output. The diode is available for free while in use. The diode is a one-way diode. Then there's the inverter with seven levels. The most significant section in a multilayer inverter is the time period, which has a combination below it. The switches must be switched off according to the time period, and then we will have the steps vies output. The latter four IGBTS are frequent, and there are two IGBTS on the bridge. It will be 5 levels if we utilise a single 1 IGBT in the bridge. If we use two bridges, we can convert seven levels, and if we use three bridges, we can convert nine levels.[11] As a result, those levels are expected to continue to climb. The three capacitors in this location store dc charge. If the first capacitor stores 5 volts, the second capacitor will have a lower voltage, and the last capacitor will have a lower voltage, and we want to construct such a combination. To run the IGBT, we need to give a certain PWM signal, which is where the pulse generator block comes in. Pulses can then be supplied at a later time. When a method asks for a PWM signal, it converts the output to a multilevel. Direct multilayer output, on the other hand, cannot be delivered to an AC load.

The multilevel steps that have been generated must be converted to a linear line by the filter, and when they are converted to a linear line, they will automatically convert to a sinusoidal waveform, which we can give to any linear or nonlinear loud, and we will be satisfied with the output.

B. Simulation results & discussion

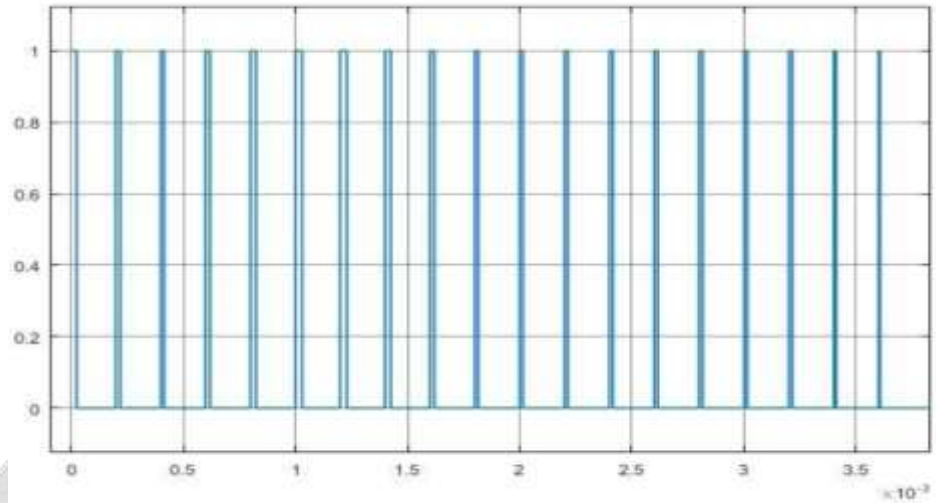

Fig 5 PWM signal of MPPT to dc to dc converter with control dc voltage source

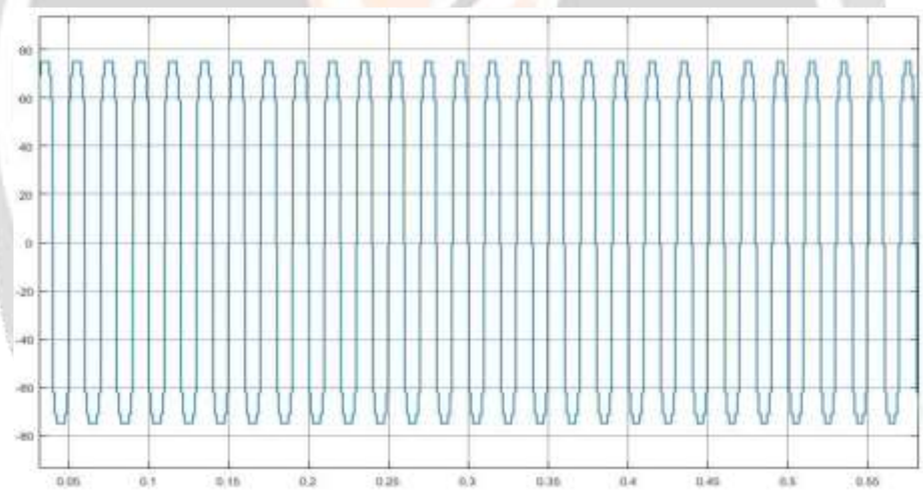

Fig 6 seven level multilevel inverter output with seven level steps

Before the desired configuration was physically built in a prototype, MATLAB SIMULINK was used to model it. Three reference signals (Vref1, Vref2, and Vref3) were compared to a triangle carrier signal to generate the PWM switching patterns (see Fig. 5). As shown in Fig 6 seven level multilevel inverter output with seven level steps & in fig 7 provide details about Filter output of single phase seven level multilevel inverter. The simulation result of inverter output voltage Vinv is shown in Fig. 8. The dc-bus voltage was set to 300 V (> 2Vgrid; Vgrid was 120 V in this case). To inject current into the grid, the dc-bus voltage must always be more than 2 of Vgrid, else current will be injected from the grid into the inverter. Therefore, operation is recommended to be between vvMa = 0.66 and Ma = 1.0. Vinv comprises seven voltage levels, namely, Vdc, 2Vdc/3, Vdc/3, 0, -Vdc, -2Vdc/3, and -Vdc/3.

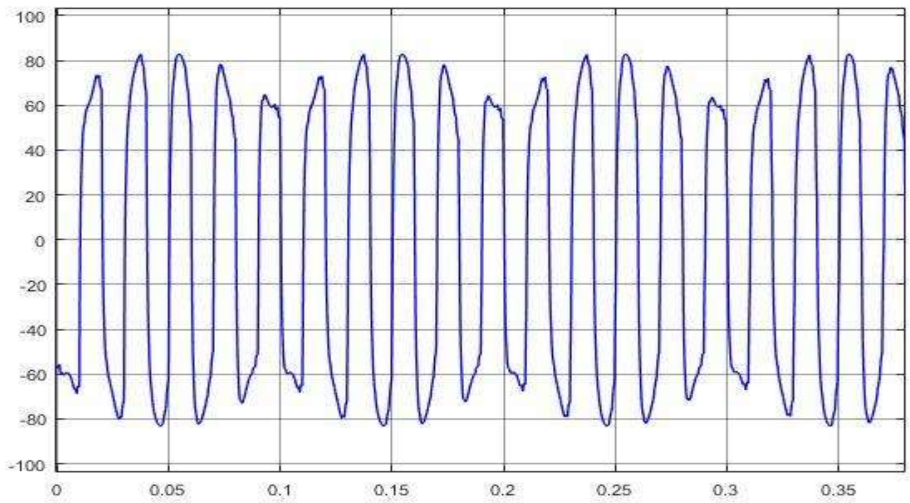

Fig 7 Filter output of single phase seven level multilevel inverter

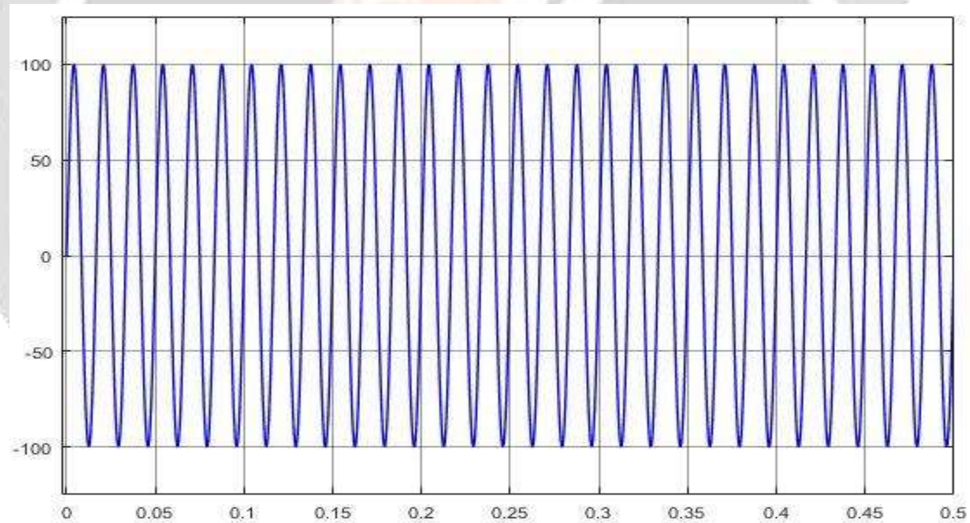

Fig 8 Final grid output of multilevel inverter

V. CONCLUSION

With only a few power switches, the proposed single phase modified seven level inverter produces almost sinusoidal output waveforms. The proposed scheme meets all requirements, including fewer capacitors, a single DC source, a compact filter, and better harmonic profiles than previous multilevel inverters. The system boosts voltages while also improving power quality. Multilevel inverters have progressed from a promising technology to a well-established and appealing option for medium and high-power applications. The ongoing development of equipment and the development of industrial applications, on the other hand, will present a new challenge and opportunity. inspire further improvement to multilevel inverter topology.

VI. REFERENCES

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