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Multiple Level Inverter Scheme for Improved Power Quality of Renewable Energy Solar Panel

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Abstract: Using a layered voltage source inverter rather than a normal one is advantageous in a number of ways and should be considered. By manipulating the voltages at the AC output ends, small quantities of harmonic distortion can be added into spiral staircase waveforms. The thing that's needed right now is a filter that takes up less space in storage. The optimistic outlook that can be attributed to photovoltaic systems' extensive use can be credited to the widespread use of solar systems. Over 635 gigawatts have been added to the global installed capacity, which is sufficient to meet approximately 2% of the world's demand for electricity. In the realm of power technology, there will be a growing demand for individuals to track down converters that they can have faith in. Power circuits are essential in order to successfully transform useable solar energy into usable electricity. Multilayer inverters, also known as MLIs, are favoured by scientists over two-level inverters due to their lower levels of electromagnetic interference (EMI), greater efficiencies, and higher DC link voltages. MLI is an abbreviation, which is why this is the case. The model was developed with the help of a piece of software for simulation called MATLAB/SIMULINK. A 40W generator prototype is now going through the testing phase. The trials demonstrate that the 27-level PWM-based cascaded multilevel inverter constructed from three H-bridges is capable of functioning properly.

Keywords: *Multilevel inverter (MLI); PV system; Maximum power point tracking; MPPT; Modified MLC converter; Leakage current suppression.*

1. Introduction

The increasing demand for energy around the world has a one-to-one relationship with the rapid rate at which fossil fuels are being burned. This causes a significant amount of greenhouse gases to be released into the atmosphere, which is bad for the environment. This has resulted in a growth in the popularity of green energy, which creates huge amounts of power while simultaneously producing small quantities of pollution. There are several types of renewable energy sources, such as geothermal heat, wind, and solar radiation, to name just a few of them [2]. The sun's light is absolutely necessary for the even distribution of energy across the entire planet. Every year, the surface of the Earth reflects and absorbs an amount of solar energy that is greater than or equal to 100,000 terawatt hours [4]. The free energy provided by the sun has the potential to make a major contribution to the advancement of renewable electricity. Although solar energy is easily accessible, its contribution to the international power system is rather insignificant. In the past three decades, there has been significant development in the utilisation of photovoltaic (PV) systems. Unfortunately, solar power still faces challenges that make it difficult for it to compete with other sources of electricity, such as fossil fuels. These challenges make it difficult for solar power to compete. Solar power has various disadvantages, some of which include a high initial investment requirement, an unpredictable output, and a low conversion efficiency [5]. We are in desperate need of a new generation that is capable of effecting a more efficient energy conversion at a lower production cost. This is necessary from both a scientific and technical standpoint. The widespread use of solar energy will be facilitated as a result of this development. inquiry after inquiry has been carried out in an effort to identify answers to these challenges and improve the commercial feasibility of solar power. In solar energy systems, the conversion of sunlight into electricity is accomplished with the use of PV cells. A solar-to-electricity conversion device is made up of photovoltaic (PV) cells, electricity converters, and an electricity management unit [6].

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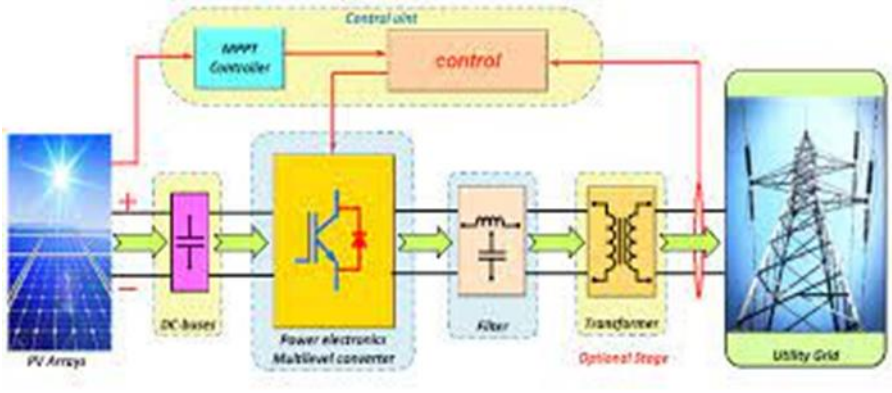

Fig 1. Conventional Multilevel Inverter for Solar

Innovative management tactics, power converter topologies, and power tracking systems have been created by engineers in order to increase the efficiency with which renewable electricity sources can be used to collect energy [7]. However, additional study into the most effective ways to use renewable energy sources to power electronic devices is still required. Energy converters and the controls that are used for them are becoming an increasingly important focus of research and development in this field because of how essential they are to the process of generating power from a variety of sources. Wind and photovoltaic (PV) energy sources, which are located at the beginning of the supply chain for energy, often have a high-performance need at this time. It is necessary for the DC/DC front-give up levels to be changeable if they are going to perform effectively in any and all scenarios. Two-level inverters are not widely used outside of specialised software and manufacturing on a small scale because of their high heat output, low efficiency, and high voltage output. These factors make them less effective. They are no longer able to manage resource-intensive applications. Multiple inverters are often used in grid-connected renewable energy systems of large scale and power [8-10]. This is because of the reasons listed above.

The following is how the study is organised: In the next section, we will discuss the research that has been conducted on the use of multilayer inverters in several different types of green energy infrastructure. In Section 3, we provide an explanation as to why the modified multilayer converter was chosen as a case study and discuss it as a case study in that section. The results of the modelling for photovoltaic (PV) systems, including multilayer inverters, are provided in Section 4. The job is finished with the fifth section.

2. Literature Survey

In 1975, the first attempts were made to convert between more than one level using converters that had three stages. These converters were a step forward in the field of level conversion. Since then, a number of distinct types of multilevel converters have come into existence [11]. In contrast, the stepped voltage pattern of the MLI is created using numerous DC sources and semiconductor switches rated for coffee energy. This contrasts with the method used by the LIM. Multiple-entry direct current (DC) sources can be generated from a wide variety of renewable and conventional energy sources, including but not limited to batteries, solar photovoltaic panels, capacitors, and fuel cells. When a number of DC sources are combined to create a high output voltage [12], algorithms are used in order to make the appropriate modifications to the power switches in order to ensure that the voltage is not lost. MLI topologies are used in a variety of different professional situations. One of these applications is in the design of energy converters for use in renewable energy systems that are grid-connected. There are several different practical uses for MLI topologies (RES), including the one that is detailed here. Recent advancements to MLIs have typically focused on reducing the amount of switches, gate driving force circuits, and DC resources in order to boost fault tolerance and energy quality while simultaneously lowering the cost of grid-connected RES [13]. This has been the primary strategy for accomplishing these goals.

In order to build a CHB-MLI, several DC sources are first connected in series, and then single-stage H-bridge (SDCS) inverters are used to convert the voltage. According to Discern 3 [14], an H-bridge consists of a DC power source, four power switches, and four power switches that only permit current to flow in a single direction. All of these components must be present. In this particular circumstance, there is a wide variety of conceivable action combinations that can be carried out on the four switches (S1-S4) that are involved. The formula $m = 2s + 1$ can be used to compute the voltage at each segment of the output. The value of s denotes the type of DC source that is being used by the cascade converter. Clamping diodes and clamping capacitors are not utilised in this design, which results in this architecture requiring less components than DCMLI and FCMLI. As a direct consequence of this, a lower number of components is required for this system. Since it does not need DC link capacitors, it does not have to worry about keeping a constant voltage [15]. This is yet another development for the better. Despite the fact that this is the case, numerous alternative DC supplies, such as converters that are more specialised and energy sources that are renewable, can be used in their stead.

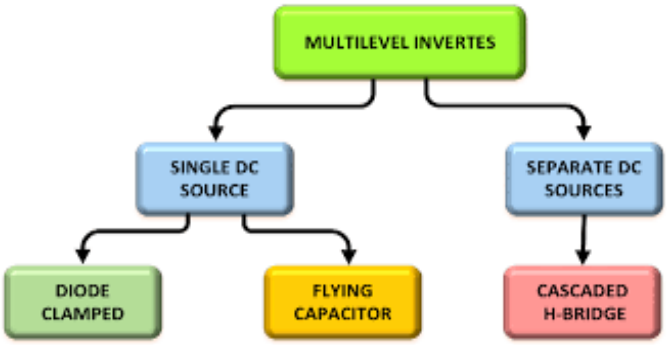

Fig 2. Classification of Multilevel Inverter

It was proposed that multilevel cascaded inverters may be utilised to link projects involving renewable energy sources (16) and static variable technologies. In order to get rid of static, the piece of equipment in issue was outfitted with a delay circuit. It is possible to wire renewable energy sources like gas cells and photovoltaics directly into the AC grid despite the fact that these sources of energy need their own DC sources. As there are presently several batteries and ultracapacitors that are capable of replacing SDCSs in these systems, it is possible that they might theoretically also serve as the primary traction drive in electric vehicles. Because of the pliable nature of this topology, it may be altered to work with a variety of other inverter topologies. When establishing distinct output voltages, different quantities of DC sources and different levels of internal voltage tiers are need to be used in order to avoid double switching. The end outcome is heightened levels of autonomy. Transformer-based solutions have been developed for CHBMLIs as a result of the fact that these devices are unable to generate their own DC power. In contrast to CHBMLIs, these have the output voltage of the isolation transformer linked in series, rather than parallel. This distinguishes them from CHBMLIs. This is because the voltages that are created by CHBMLI are connected in parallel to one another. [17] These isolation transformers each have their own unique characteristics, in spite of the fact that they have a similar layout.

3. Proposed Methodology

MLIs have been the subject of intensive research and development in order to make them even more efficient. This is the case in spite of the fact that MLIs have a number of advantages that other kinds of inverters do not. As a result, a modified multilayer inverter was developed by constructing MLIs with a reduced number of power switches and by making other modifications to the MLI topologies. Because there are fewer switched MLIs, the device can be made smaller, it can make do with less memory, and it can be manufactured for less money [18]. Because it requires less switching than other MLI topologies, it may be constructed in sub-sections with fewer switches than the normal eight switches. This allows it to be deployed more easily. At last, a filter is attached to the output of the inverter so that there is an even smaller amount of THV. In the experiment, a variety of switching frequencies and inverter settings were compared for their levels of performance. It was found that the setup that produced the least was the best option. The five-story layout was selected because it was easier to wire and had a lower THV than the other options. MLIs are well-suited for high-voltage and power-hungry buildings due to their modifiability as well as their ease of use. It has been suggested that sending the pressure to a number of different additives will make it possible to use greater voltages without the necessity of using additives with high ratings. Therefore, DC-link voltage inverters that are able to produce 10 kV are able to rent MLIs. Additionally, the costs that are associated with implementing a change have become less expensive. In addition to this, a five-stage inverter has the potential to cut maximum load losses by as much as sixty percent.

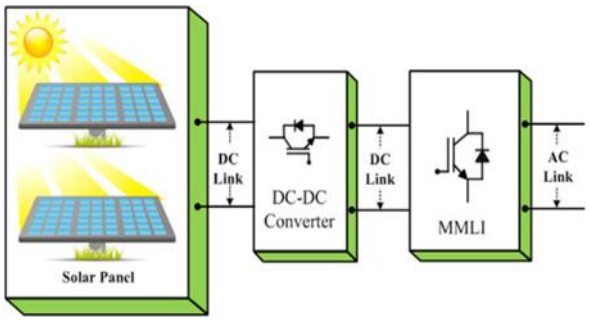

Fig 3. Proposed Solar based Multilevel inverter

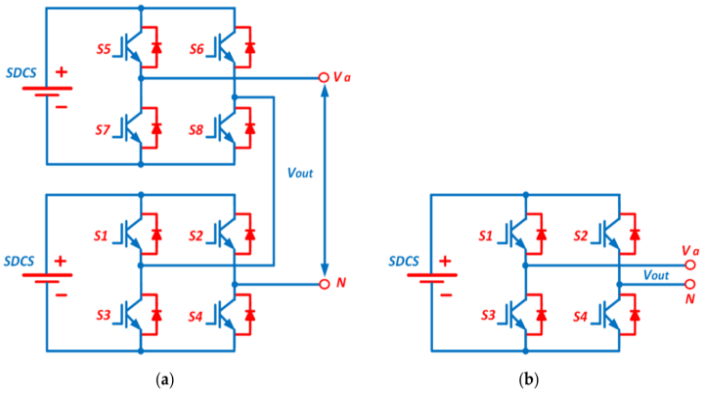

Fig 4. Schematic diagram of Proposed methodology circuit

Despite the fact that MLIs are already considerably superior to other inverters in many areas, they have been subjected to extensive research and development in order to make them even better than they now are. As a consequence of this, we made some modifications to M and constructed MLI using fewer power switches, which resulted in a modified multilayer inverter.The fact that researchers are looking into this type of inverter demonstrates how important it is to the sector. In contrast to the three-segment and five-level inverter that was supposed to be generated, the inverter cell only produced a single-segment inverter with six switches. When two switches in this device are subjected to a voltage of 200 V, the device generates distinct results for each of the other four switches. This indicates that the device needs not one but two different data transfer rates to function properly. The research suggested using an inverter with 11 levels and 14 switches, despite the fact that there is data suggesting that a device with fewer switches would be more effective. Because it makes use of switches with low scores, the device is able to display the level of performance that was intended for it when the switches are connected in the "go" order. An inverter that has 11 stages was utilised so that this theory could be put to the test. The machine was constructed with fewer buttons as a result of the ingenious modification that was made to the cell connection. Connecting many battery cells in series allows for the production of voltages that are distinct from one another. This configuration works well with capacitors and other DC resources in PV systems that are connected to the grid [19]. In order to construct the gadget, the polarity of the DC supply must be switched as required. In addition to that, the performance of the machine was evaluated with a 5-degree single-phase inverter.

The range of outcomes that are feasible will be shown as follows:

When it comes to topologies, I. Because there are fewer MLIs that have been flipped, the device has a smaller footprint, requires less memory, and has reduced manufacturing costs [18]. Because it requires less switches than alternative MLI topologies, it is possible to partially implement it with fewer than the typical eight switches. This is due to the fact that it is more efficient. At last, a filter is attached to the output of the inverter so that there is an even smaller amount of THV. The objective of the test was to assess how well different generator settings and switching frequencies performed. It turned out that the configuration that brought about the worst possible outcome was the one that should be used. Because it was easier to wire and had a lower THV, the five-story layout was selected for the building. MLIs are perfect for high-voltage and high-power buildings since they are easy to assemble and require little effort. According to the theory, higher voltages can be utilised because the pressure is being dispersed over a greater number of additives. MLIs can be rented for use with voltage transformers for DC-links that produce 10 kV. Additionally, the cost of migrating has become less expensive. Using an inverter with five stages, it is feasible to cut peak load losses by as much as sixty percent.

$$N = 2^{m+1} - 1 \qquad (1)$$

where m represents the Level Modules number, and the number of connected switches in the circuit is given by:

$$n_s = 2 * m + 4 \qquad (2)$$

The dc input voltage given to i th module number varies with the particular module no. as:

$$V_i = 2^{(i-1)} * V_b \qquad (3)$$

Because of the many advantages it possesses, photovoltaic (PV) power generation has recently attracted a lot of attention. These benefits include the potential to provide energy output that might satisfy top load needs, as well as the ease of allocation, longer life, lack of noise, loss of pollutants, speedier set up, high mobility and item portability, and the capacity to meet top load criteria. Additionally, these benefits include the potential to provide energy output that might satisfy top load requirements. PV arrays offer a wide variety of possible applications in the commercial sector, some of which include, but are not limited to, the following: battery charging devices; solar-powered hybrid autos; solar-powered power infrastructure for satellite television; solar-powered water pumps; and a great deal more. As a direct result of this, a number of nations are devoting substantial resources to the research and development of programmes pertaining to clean energy. Despite the fact that PV power systems are constrained by a number of factors, DC-DC voltage converters can be broken down into one of three categories: boost, greenback, or buck-boost. If you know the voltage that you want the DC-DC converter to output, you will be able to select the component that is most suited for producing that output. Photovoltaic (PV) systems can be converted into dependable feeder resources by making use of batteries to create stable voltage ranges that correspond to a wide variety of load types. Either you can use the battery to swiftly store energy in it, or you can use it to defend yourself from power

interruptions. Photovoltaic cells on the outside of a solar panel can be connected in either a collection-parallel configuration or a series configuration, or both [20].

Indicator 3 gives a succinct description of the characteristics that solar electricity contains by making use of test factors such as PV cell home location (Isc). Isc is a parameter that is sensitive to the amount of light that is present, and it is responsible for defining the maximum amount of current that a cell is capable of producing. This maximum amount of current is determined by a cell's capacity to produce that maximum amount of current. Voc, on the other hand, refers to the greatest voltage that a solar cell is capable of producing while still being able to function correctly without the assistance of any additional external power source. In other words, it is the maximum voltage that a solar cell is capable of producing while being independent of any additional power source. It is possible to think of PV cells as analogues of a similar circuit that is already in existence.

4. Results & Discussion

The suggested cascaded multilevel inverter with changing DC input was simulated by using the MATLAB/Simulink software tool under a variety of loading circumstances. After that, a performance study was carried out based on the THD values obtained under different load circumstances.

Table 1. Parameters of Proposed Multilevel Inverters

Parameters	Value
Phase	Single
Frequency	50HZ
V_{dc1}	2
V_{dc2}	8
V_{dc3}	26
Power Rating	1KW

The Simulink Multi Level Inverter, which includes a DC supply, an inverter, and a voltage and current meter, is displayed in Table 1. Sinusoidal pulse width modulation regulates the gate pulse of inverter switches, which regulates the switch.

Table 2. Total Harmonic variation for PV inverter having non-linear load with and without filter

Parameters	TDV	
	With Filter	Without Filter
Inverter Output Voltage	12.2	12.1
Inverter Output Current	4.5	5.8
Load/PCC voltage	2.1	12
Load Current	1.2	9.7
PV current	3.5	5.8

A nonlinear load of a diode bridge that is connected to the PCC without an LC filter is used to study the grid-connected solar PV system. On the dc side of the diode bridge, the nonlinear load is made up of R and L, which are each 20 and 5 mH. Table 2 shows what happens to the voltage, current, and PCC voltage of the load when it is removed for 0.04 to 0.08 seconds.

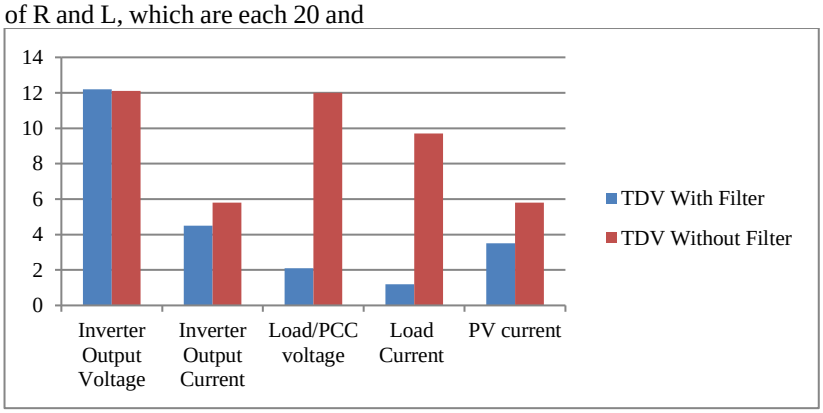

Fig 5. Total Harmonic variation for PV inverter having non-linear load with and without filter

Table 3. Simulation results for PV Multilevel inverter

Load Power Factor	Load Current		PV Current	
	RMS	THV	RMS	THV
0.7	7.7	1.8	5	7.7
0.8	7.8	1.5	4.6	6.8
0.9	8.1	1.4	4.3	5.7
1	8.8	2.3	4	4.2

Table 3 displays the RMS values of the grid voltage/PCC voltage, load current, and grid current, as well as the power factor variations resulting from the load. Based on the data in the table, it appears that regardless of the value of the power factor, the THD of the PV current and PCC voltage remains relatively constant. The THD of the load current, however, worsens with increasing load power factor. Calculations for the aforementioned harmonics are made when no filter is present in the system.

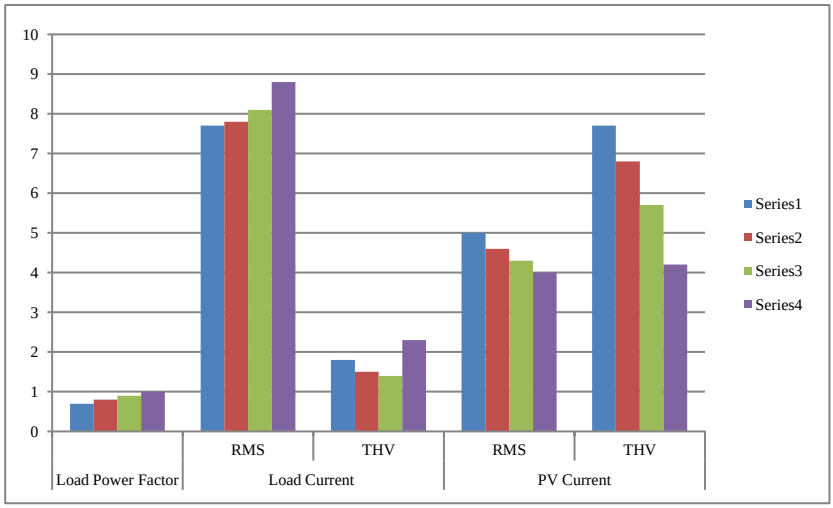

Fig 6. Simulation results for PV Multilevel inverter

5. Conclusion

This article has barely scraped the surface of what multilayer inverters are capable of doing in order to illustrate the demand for additional research. By presenting a concise analysis of the properties of multilayer inverters, the purpose of this study is to draw attention to the requirement for new inverters or diverse mixes of inverters for grid-connected and PV systems. Several elements of MLIs, including their variety, advantages, problems, and potential to improve energy conversion in modern power systems, were dissected in considerable detail in the previous section. In light of the data that has been provided in this article, it has been determined that a modified strategy that makes use of typical MLIs at more than one level is recommended. Modified multilevel inverters (MLIs) are an alternative to photovoltaic (PV) cells and other forms of renewable power systems. They excel in areas like as compact design, low total harmonic distortion (THD), and high energy conversion efficiency. These initiatives targeted, in a similar fashion, the most advanced MLIs grid-connected PV structures, as well as the most advanced leakage control techniques.

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