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Operational Analysis of Renewable Energy Based Multilevel Inverter induction Motor Drives

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ABSTRACT

Since the start of civilization, the sun has been a source of light, and study has shown that it has a potential and bright future as an alternative to the most important conventional sources of energy, such as coal, gas, and petroleum, which are rapidly depleting. Environmentally friendly renewable energy (RE) technologies are being researched all over the world. A 100 kW photovoltaic (PV) system is modeled in the MATLAB/SIMULINK environment in this paper. Under changing environmental conditions, the performance of a PV system with an acceptable power electronic converter with an AC load in standalone mode is examined and described in this paper. Maximum power point tracking based on the Incremental Conductance (IC) algorithm was used to get the most out of the PV system under various illuminations and panel temperatures. The photovoltaic generation model in a grid-tied mode is also proposed in this paper, where the power is supplied to an isolated individual load and the inverter is typically controlled by a current mode control to deliver a sinusoidal voltage to the load.

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1 INTRODUCTION

Because they provide lower energy consumption, higher system efficiency, enhanced product quality, good maintenance, and so on, power electronic converters, particularly dc/ac PWM inverters, have been expanding their spectrum of use in industry. It is difficult to connect only one power semiconductor switch directly to a medium voltage grid. As a result, in high-power and medium-voltage applications such as laminators, mills, conveyors, pumps, fans, blowers, compressors, and so on, a multilevel power converter structure has been introduced as an alternative. Multilevel converters are a cost-effective solution that not only achieve high power ratings, but also allow for the use of low-power applications in renewable energy sources like photovoltaics, wind turbines, and fuel cells, which can be easily interfaced to a multilevel converter system for a high-power application. Multilevel converters were first used in traction, both in locomotives and track-side static converters [4]. Power system converters for VAR correction and stability enhancement [5], active filtering [6], high-voltage motor drive [3], high-voltage dc transmission [7], and, most recently, medium voltage induction motor variable speed drives [8] are some of the more recent applications. Industrial medium-voltage motor drives [3, 9], utility interface for renewable energy systems [10], flexible AC transmission system (FACTS) [11], and traction drive systems [12] are all examples of multilayer converter applications.

Inverters in these application areas should be capable of handling high voltage and huge power. Because series connection of switching power devices such as gate-turn-off thyristors (GTOs), integrated gate commutated transistors (IGCTs), and integrated gate bipolar transistors (IGBTs) allows reaching much higher voltages, two-level high-voltage and large-power inverters have been designed with series connection of switching power devices such as gate-turn-off thyristors (GTOs), integrated gate commutated transistors (IGCTs), and The series connection of switching power devices, on the other hand, has significant drawbacks [13], namely, non-equal distribution of applied device voltage across series-connected devices, which can cause the applied voltage of individual devices to be much higher than the blocking voltage of the devices during transient and steady-state switching operation. Several multilayer inverter and converter circuit topologies have been explored and used as solutions to efficiently handle the above-mentioned challenges. The multilayer inverter's output voltage is composed of numerous levels generated from many DC voltage sources. As the number of voltage levels grows, the quality of the output voltage improves, allowing the number of output filters to be reduced.

Multilevel converters are an idea that has been around since 1975. In 1975, the cascade multilayer inverter was proposed for the first time [14]. To create a staircase AC output voltage, separate DC-sourced full-bridge cells are connected in series. With the three-level converter [15], the word "multilevel" was coined. Several multilayer converter topologies were developed as a result [16]. Diode-clamped multilevel inverter systems, also known as Neutral-Point Clamped (NPC) inverter schemes, were first presented in 1981. Capacitor-clamped (or flying capacitor) multilevel inverters [18] and cascaded multilevel inverters [19] were proposed in 1992 and 1996, respectively. Despite the fact that the cascade multilevel inverter was conceived earlier, it was not widely used until the mid-1990s. For motor drives and utility applications, the advantages of cascade multilayer inverters became obvious. Because of the increased need for medium-voltage high-power inverters, the cascade inverter has sparked a lot of interest. In regenerative-type motor drive applications, the cascade inverter is also used [20, 21]. Recently, numerous innovative multilayer inverter topologies have appeared. Generalized multilevel inverters [22], mixed multilevel inverters [23], hybrid multilevel inverters [24, 25], and soft-switched multilevel inverters [26] are examples of this type of inverter. By expanding the number of voltage levels, these multilayer inverters can increase the rated inverter voltage and power. They can also raise equivalent switching frequency without increasing real switching frequency, minimizing inverter output voltage ripple and electromagnetic interference effects. There are numerous approaches to implement a multilayer converter. To create multilayer waveforms, the simplest techniques include connecting standard converters in parallel or series [27]. More sophisticated architectures place converters within converters more effectively [28]. The multilayer converter's voltage or current rating becomes a multiple of the individual switches, allowing the converter's power rating to exceed the limit set by the individual switching devices.

II. The Need for Renewable

Renewable energy is energy that is derived from natural resources such as the sun, wind, waves, or geothermal energy. These are renewable resources that can be recycled naturally. As a result, these sources of knowledge are regarded endless in comparison to the depletion of traditional fossil resources [1]. The worldwide power shortage gives clean or renewable energy a new drive to expand or mature. [2]. Aside from the global drop in fossil fuel transportation, another important reason fossil fuels aren't working is the pollution caused by burning them. In contrast, it is commonly known that renewable energy sources are cleaner than traditional energy sources, or that the energy produced has no negative pollution consequences.

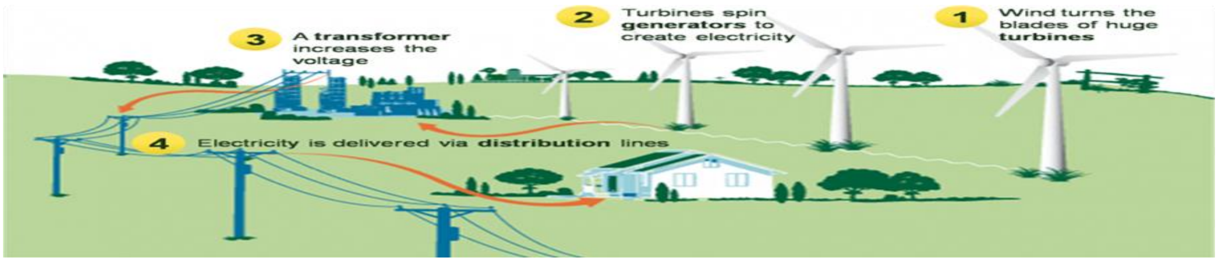

Figure 1: Solar and Wind Power Hybrid Energy Plant

III. Micro grid operating mode

Mains Connection Mode: Mode of mains connection: The Micro grid is connected to the mains via a point coupling coil (PCC) and a circuit breaker under typical operating conditions (CB). The Micro grid's voltage and incidence are synced with the mains. The power distribution to the distributed load is shared by the mains and the Micro grid. When the main power supply is insufficient, the Micro grid can offer extra electricity to balance the load. Assume a malfunction develops in one of the micro-power sources. In that circumstance, the remaining operational micro-power sources will offer extra power to compensate for the power shortage produced by the malfunctioning power source.

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Island Mode: Disconnect the MG from the mains on the PCC in the case of a mains failure by using a switch that isolates the MG from the mains. Following disconnection from the mains, the MG will operate exclusively according to a predefined control plan, gradually increasing the power produced by all micro-sources to supply power to the load. Even if there is a power outage, the load can be turned on this manner. Some non-emergency loads can be disconnected if the load requirement exceeds the micro-source capacity in island mode. At least one converter should be operated under V/f control to maintain mains voltage and frequency. Only when the voltage error is less than 3%, the frequency error is less than 0.1 Hz, and the phase angle error is less than 100 may the MG be reconnected to the mains after troubleshooting [3].

IV. CATEGORIES OF SWITCHED-CAPACITOR MULTILEVEL INVERTER (SCMLI)

The number of voltage levels that switched-capacitor multilevel inverters may create is classified in this research. Five-level, seven-level, nine-level, and N-level topologies are presented in this section. These topologies can also be distinguished by the amount of gain they give, the number of power switches they use, and whether they are made up of complete H-bridge, half H-bridge, or no bridge at all. Voltage balancing is built into some topologies, whereas in others, voltage balancing is achieved by the use of particular switching mechanisms. MLIs are designed to connect renewable and sustainable energy supplies to the distribution grid and local loads in a variety of ways. MLIs are most commonly employed in medium and high-voltage applications. However, traditional MLI is less suitable for high-voltage applications since achieving high voltage necessitates a large number of components or isolated dc sources, and high-voltage stress might occur across switches in some circumstances. Furthermore, typical MLIs lack the capacity to raise voltage. In general, the voltage stress across switches of hybrid MLI topologies is considerable, which is unacceptable for high-voltage applications because voltage stress rises with voltage increase. SCMLIs are a viable option since they require far less dc sources, switches, and diodes, and they can also enhance voltage. As a result, SCMLIs are preferred for medium- to high-voltage applications, such as variable speed drives, electric vehicles, and grid-connected renewable energy systems, and provide higher performance.

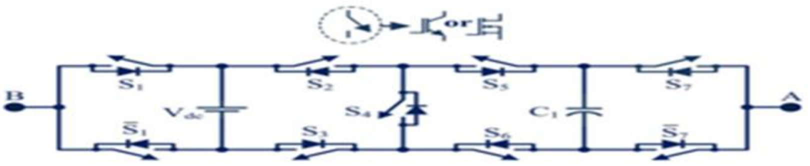

Fig 2. Five-level proposed topology

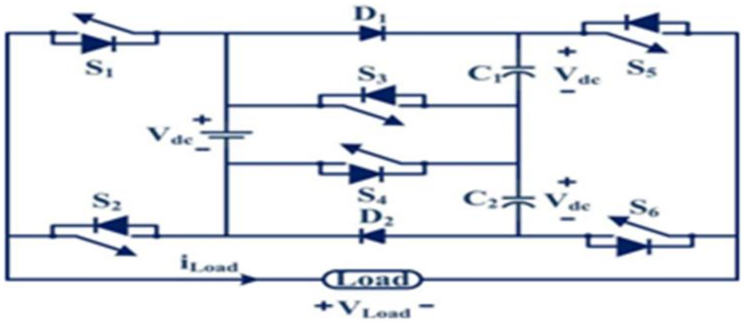

Fig 3. Five-level SCC

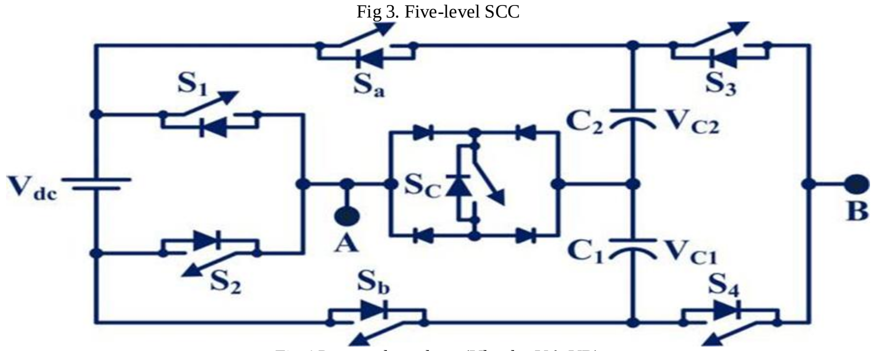

Fig 4.Proposed topology (Vload = VA-VB)

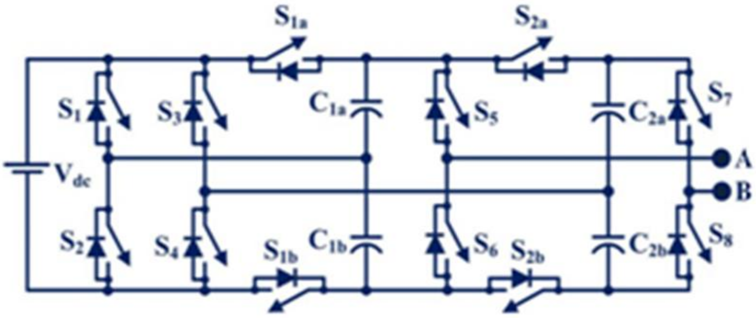

Fig 5. Bridge modular switched-capacitor topology

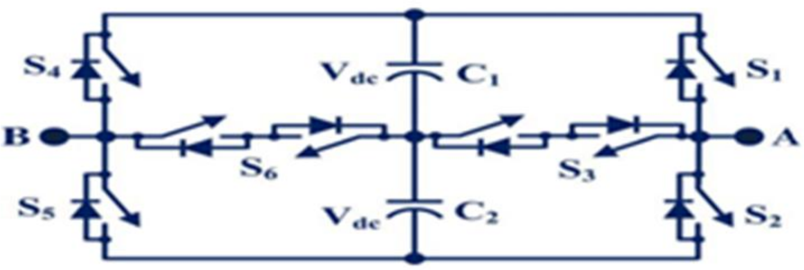

Fig 6. Symmetric five-level T-type converter

Because the peak inverse voltage across each of the switches is uniform, developing five-level output with single-stage circuitry requires only nine switches, one capacitor, a single voltage source, and no diode. LFS is for line frequency switches, and ISC means for intermediate switching cell (connects dc source with switched capacitor) (S1 and S7 operate once in a half cycle of input fundamental voltage). The topologies feature built-in voltage balancing and may create bipolar boosted voltage without the use of an end-side H-bridge; thus, they are cost-effective because no additional voltage balancing circuits are required. Figure 4 depicts a single-phase five-level inverter with two half-bridge cells on both end-sides of SCC. As shown in Figure 2, the topology consists of an H-bridge with a modular switched-capacitor circuit, with the modular component consisting of eight

MOSFETs and four capacitors. 5. One of the proposed circuit's advantages is that the switches can be operated at line frequency, lowering switching losses. The pulse-width modulation approach can be used to provide capacitor voltage balance, which is not inherent. The topology is a three-level T-type converter with a single dc source, which could be a battery, a fuel cell, or anything else. By cascading the structures, this simple module can easily be extended up to N levels. The topology is advantageous because it has built-in voltage balancing between capacitors, can generate bipolar voltage, is easy to extend, and has low overall harmonic distortion..

V.NINE-LEVEL INVERTERS

A small nine-level packed-U cell inverter is presented to simplify topological setups.
28 The standard components, namely a T-type neutral point clamped and a half-bridge with two identical dc sources and two switches, are combined to make this topology. A three-phase nine-level switched-capacitor inverter topology29 is similar. The architecture is appropriate for all low-voltage applications with less switches, capacitors, and dc sources since it is constructed using a T-type three-level cell and an active neutral point clamped (NPC) for all phases. However, capacitor voltage balancing is not inherent, thus phase disposition modulation is used to balance the voltage across flying capacitors and the neutral point. The voltage required in grid-connected systems is considerable; however, certain multilevel inverters are unable to give enough voltage to the grid since the output voltage supplied by fuel cells and solar systems is low in comparison to the grid. Boosting circuits with transformers and inductors are sometimes used to achieve the requisite voltage,33-35 making the circuitry big and unwieldy.
The topologies36-39 of switched-capacitor multilevel inverters presented below can give a boosted nine-level output voltage that is four times the input voltage. In the preceding level, these topologies do not require any additional boosting circuitry. Figure 20 shows a boost-type nine-level inverter that outperforms nine-level CHB,40 FC,41 NPC,42 ANPC (active neutral point clamped),43 and SCISPC (switched-capacitor inverter employing series/parallel conversion)45 inverters, although it requires an isolated dc power source. Similarly, the voltage stress across switches in Figure 21's nine-level boost inverter does not require a back-end H-bridge, and the voltage stress across switches is limited to twice the input dc voltage. 37 A quadruple boost nine-level SCMLI, on the other hand, has a lower total standing voltage since it does not require a back-end H-bridge, and the number of devices in the topology is also reduced. 38
Because cascaded multilevel inverters (CMIs) are widely used for generating high output voltage, but CMIs require a large number of isolated dc sources, which is undesirable, the topology39 is created by connecting H-bridge cells in series and using capacitors in place of numerous dc sources. As a result, the capacitors can be charged with just one dc source. Because capacitors are charged in the charging stages of switched-capacitor inverters,

VI.SIMULATION AND RESULTS DISCUSSION

CHB MLI is widely utilized in PV-based medium voltage micro-grid systems. Figure 1 shows the functional block diagram of the PV-fed MLI system. Using a maximum power point tracking (MPPT) controller with a DC-DC converter, the inverter input voltage is kept constant. The relatively constant output voltage from the DC-DC converter is delivered to the inverter to connect with the ac micro-grid system, regardless of environmental fluctuations. These days, grid-connected PV systems are becoming increasingly common. A PV generation set-up, which can be a single module, a string of series-connected modules, or an array of parallel-connected strings, lies at the heart of the system. PV inverters, which come in a variety of topologies, are in high demand these days [13]. Several voltage and current transducers are coupled to the MPPT's input side via a closed loop control system [14]. The output frequency and voltage that is delivered to the grid are controlled by the inverter. Figures 7 and 8 depict a general block diagram of Grid-Connected PV Systems and Grid-Connected Solar PV Fed VSI Systems, respectively.

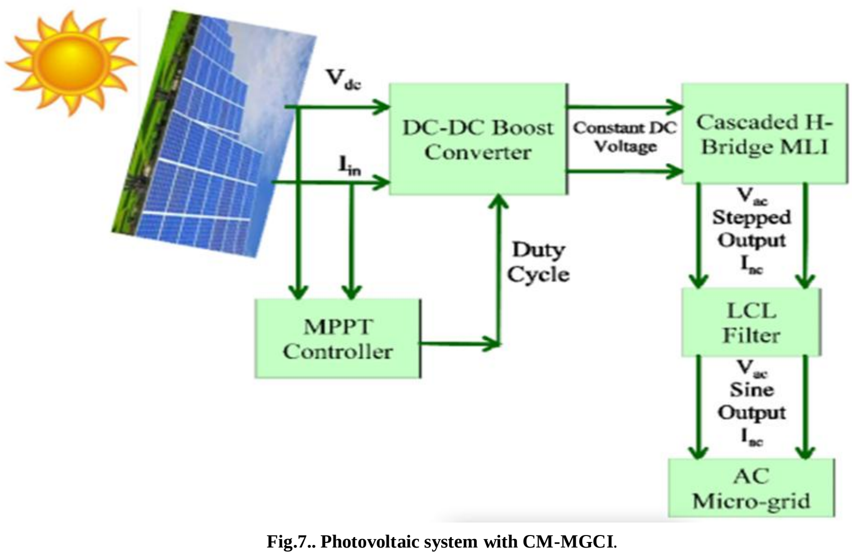

Fig.7.. Photovoltaic system with CM-MGCI.

VII. PROPOSED MODIFIED H-BRIDGE CM-MGCI

We presented a modified H-bridge for a symmetrical approach in this paper, and the performance of the proposed 11-level twelve-switch topology was simulated and analyzed using LSC-SPWM in the MATLAB/Simulink environment. Figure 5 shows the topology of the desired modified H-bridge MLI for a three-phase PV-fed micro-grid system. The suggested micro-grid connected H-bridge inverter construction has the same basic requirements as a regular CHB topology.

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VIII. PROPOSED MODEL

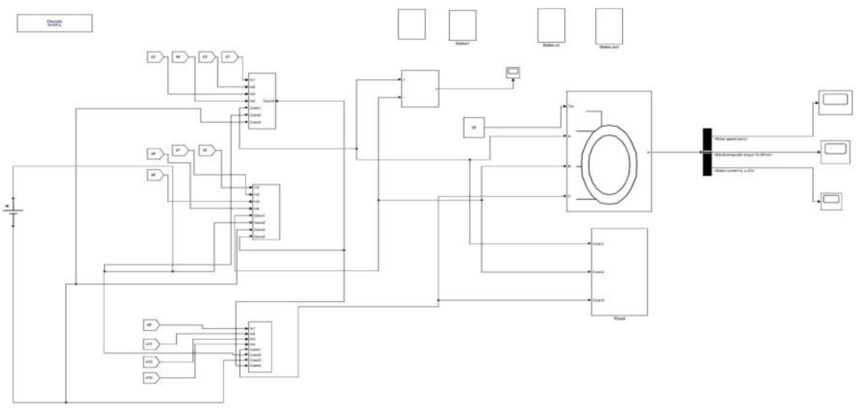

Fig .8 proposed model

To evaluate the configuration response and analyze the performance, the suggested modified H-bridge CM-MGCI is created in MATLAB/Simulink. Because there are six separate half H-bridges in this MLI setup, 12 level-shifted carriers are required. Figure 8 shows the output voltage and associated harmonic distortion profile of the redesigned reduced switch H-bridge MLI. The THD of the proposed topology is 9.21 percent, which is 3.82 percent less than the value of typical CHB MLI, with ma of 0.85 and mf of 40. The proposed design's THD value is also compared to the other published designs in Table I. Our suggested improved H-bridge has a superior THD profile than those previous similar efforts given in [9]-[12], as shown in the table. Furthermore, compared to the topologies in [9]-[12], our topology employs fewer power switches. The THD of the 13-level output voltage is 10.70 percent when using the topology shown in [10]. Because the THD increases as the voltage level decreases, the 11-level voltage must have a THD greater than 10.70 percent in this topology. The arrangement in [11] also has a 9-level output voltage with a THD of 17.18 percent and a modulation index of 0.85. It can plainly be seen that the THD for this topology's 11-level design will not be less than 13%. As a result, the THD of our modified H-bridge is lower than that of contemporary reduced switch MLI topologies.

IX.SIMULATION RESULTS

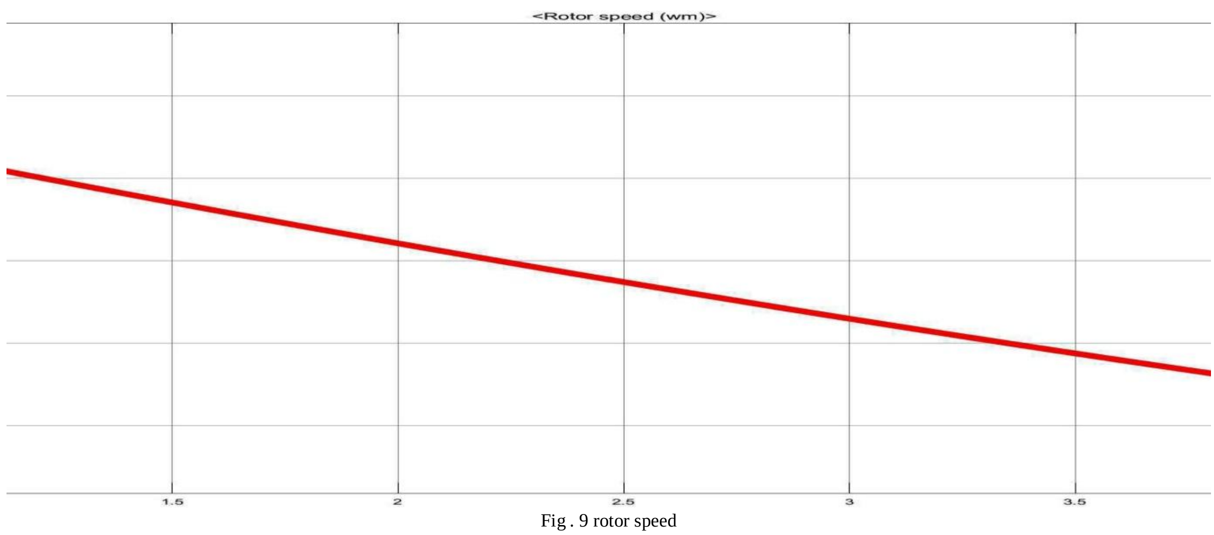

Fig . 9 rotor speed

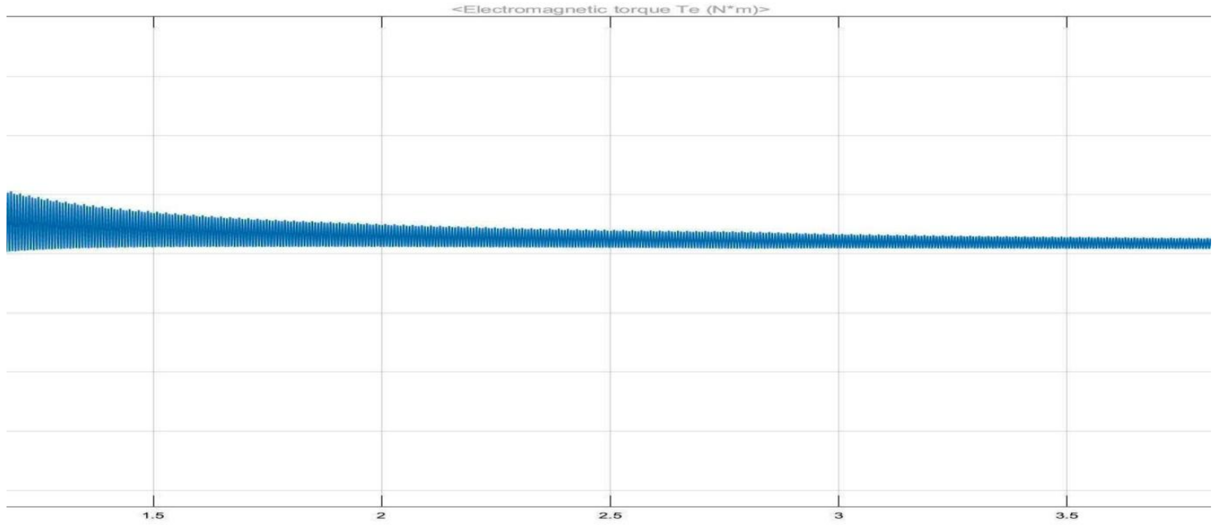

Fig.10 torque characteristic

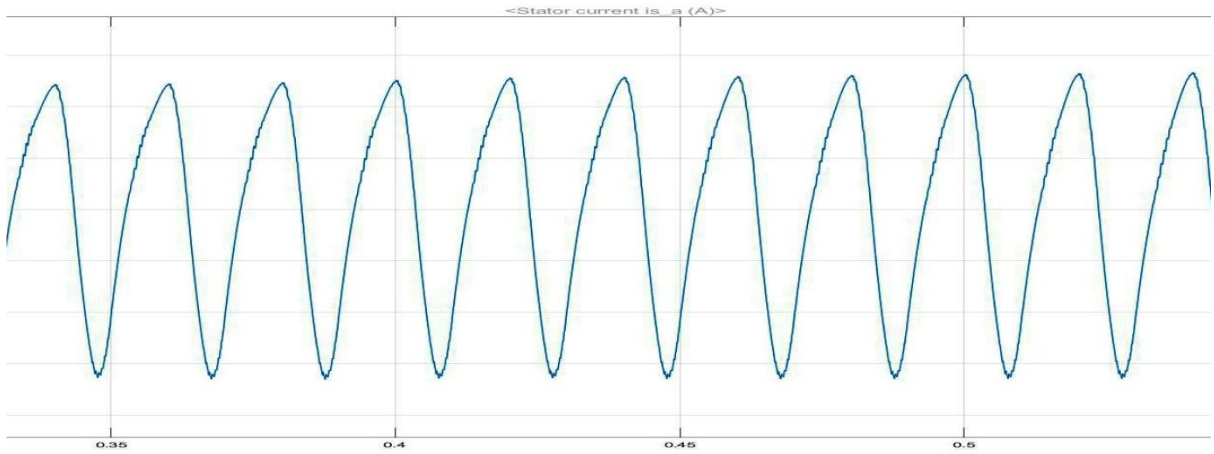

Fig 11. Stator current

X. CONCLUSION

To increase the system's performance, a redesigned design for the multilevel H bridge inverter has been proposed. The proposed version's effectiveness and validity are proved using the MATLAB/Simulink environment. The suggested inverter has a lower THD, uses fewer power devices, and has a lower power loss. Due to these characteristics, the proposed topology outperforms traditional architectures. As a result, this system could be a viable alternative to inverters in PV-based micro-grid applications. With the help of an MPPT-based DC-DC boost converter and a three-phase VSI, the proposed model clearly displays the modeling of a grid-tied PV system. The MPPT's job is to get the most power out of the PV cell while maintaining a high efficiency. The most significant feature of the VSC controller implemented here is that it keeps the line to line voltage constant regardless of the load. The stream does, however, have some ripples, which is acceptable. In the case of a grid-connected PV system, the controller requirements are significantly different than in the case of a freestanding PV system. Grid-connected systems necessitate both voltage and current control strategies, whereas freestanding systems simply necessitate a voltage control scheme. The model completely verifies the influence of irradiation and temperature on PV output, i.e., as irradiation increases, power output increases, but as temperature rises, power output falls. Multilevel inverter-related technologies are now being researched and developed all around the world. This thesis focuses on the basic principles of various multilevel inverters, modulation techniques, and harmonic analysis of induction motor drives

XI FUTURE WORK

Despite the fact that this dissertation has covered the majority of the intriguing difficulties and challenges associated with Cascaded multi-level inverter induction motor drives, there is still more work to be done in the future. The fault-protection study for cascaded multi-level inverter induction motor drives is the first section. The design of a fault protection scheme to improve the ride-through capability in diverse fault scenarios remains a significant problem due to the large number of semiconductor devices and passive components. The malfunctioning module must be changed while the converter is running in industrial applications. As a result, an additional switch is required at the module connections' terminal locations. When such an error occurs, experimental testing indicate that the voltage is evenly distributed across the remaining modules, matching the DC-link voltage as before. This ensures the system's stability in the event of a module failure. There will be further research done in this area as well.

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