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Power Quality Maintenance In PV System By MMC Using Artificial Neural Networks

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Abstract: **Pulse Width Modulator (PWM) Modular Multilevel Converters may be controlled using a unique control technique in this paper. There are two parts to the MMC in this case: the upper and lower arms. Cross coupling interactions between submodule and system level parts using neutral dependent sources are recognized by the novel average method used here. The primary goal of this strategy is to keep the PWM modulated DC bus's inherent balance while also improving damping. Improve the damping frequency of the PWM modulated MMC to preserve DC system balancing. The primary goal of this article is to keep the circulating currents and voltage balance in check. To get the necessary ripples analytically, between circulating current references and capacitor voltage ripples is used in this paper to swiftly determine the right circulating current references. The MMC's sophisticated simulation model is used to retrieve the training data. Once the mapping relationship has been established, the ANN is trained using the input-output data to provide the appropriate circulating current references. Arm currents, DC link AC current, and AC grid voltage and current are all included in the simulation findings**.

Index Terms: **PWM, MMC, Voltage Ripples, ANN, AC grid.**

I.INTRODUCTION

There is a direct correlation between the increase in power consumption and the increase in power system losses. When compared to traditional DC link converters, the Modular Multilevel Converters provide more accuracy in regulating power losses [1]. Cascaded half-bridges have been designed for high-power appliances, so they don't need individual half-bridge DC links. High-voltage direct current (HVDC)[2] or DC systems are increasingly requiring MMCs. The DC link's circulating currents and voltage balance may be adjusted most easily by using the converter on the grid side [3]. Active power filters (APFs), static compensators STATCOM and renewable energy storage systems and high-voltage motor drives can be used in the Flexible AC transmission system FACTS [4–6]. Between the conventional converters and MMCs, the fundamental difference is between each phase leg and the same DClink in the MMCs. The inter-phase and inter-arm DClink voltage can be balanced [6] by injecting the fundamental frequencies of circulating currents in positive and negative sequences. Reduced voltage ripples in DClink [7–9] are made possible by the second-order harmonic flow in the circulating currents. DClink power quality can be improved by several methods for controlling the flow of current and balancing voltage in imbalanced systems. The MMC increases the dynamic performance of the balanced positive/negative-sequence control techniques under unbalanced conditions [10].

For odd or even N, the submodule PWM can be reduced by adjusting the phase of the upperarm and lowerarm of the MMC phase leg arms, hence reducing switching frequency harmonics (N+1 modulation) [11, 12]– [16]. Harmonics of lower order are formed at the DC link interface between each submodule, and this voltage ripple cannot be regulated by PWM. Using inductors or capacitors with short-arm diodes or coils, lower-order harmonics are reduced to a modest size to minimise the current score converter switching [17–36]. To reduce lower order circulating currents, direct control and indirect control approaches are used. The ANN controllers and the positive/negative sequence double frequency dq transformation will be used to minimise the spinning frame directly. [18]

In addition, an unbalanced three-phase system [11], [24] and a practical I-phase system are necessary for the use of this technique. It is necessary to design an easy controller in order to eliminate even harmonics

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[30]. The DC link submodule's dynamic responses of the upper and lower arms had been conquered using a variety of compensating approaches.

The non-linear H-infinity output current controller and predictive control regulator make this paper's overall control structure different from the frequently used MMC control structure. Implementing a non-linear controller in this new control framework may be difficult due to the need for a high level of expertise. In order to compensate for SM capacitor voltage ripples caused by an imbalanced grid, it is necessary to design simple and generalizable control algorithms. An artificial neural network (ANN) trained to map the link between circulating current references and SM capacitor voltage ripples is proposed in this paper, which is both flexible and computationally light. The injected circulating current references are automatically derived using this ANN model under various grid settings. Additionally, appropriate capacitor-voltage-ripple values can be acquired explicitly and restricted to a predefined working range. Experimentation has shown that simulation data can be used to train an artificial neural network (ANN).

Using DC link voltages, the feedforward system may also reduce lower-order circulating currents while compensating for the modulation of the upper and lower arms separately. An external inter-arm is required to manage the voltage balance while using this technology since the average DC voltages are marginally stable[33], [34]. The use of computed values instead of measured DC voltages in a closed loop has been proposed [35]. An integrated PWM modulate MMC and ANN controller control approach is developed in this study to achieve efficient performance under DClink voltage imbalanced situations and harmonic circulation currents. The proposed ANN PWM modulate MMC block diagram is provided here. The mathematical explanation of ANN PWM modulated MMC is outlined in depth in the next paragraphs. In addition, when AC load current contains numerous frequencies, the calculations become impossible. In the conclusion, MATLAB/Simulink is used to develop and analyse the Schematic of the ANN PWM modulate MMC.

II LITERATURE REVIEW

Qing Du et al. proposed a series half bridge converter with a high input power and parallel outputs (2012). All outputs of this circuit have been isolated from the input so that no reciprocal effects can occur. This prevents oscillations. A thorough examination of its layout, principles of operation and relationships among its numerous components was conducted by the researchers. Transfer function discrepancies and interruptions owing to switching time delays and fluctuating input voltages are examined. In order to achieve effective control at steady state, smooth mode transition and a decrease in the harmful effect caused by input voltage perturbation, a combinational control approach and compensation methods were described.

Zhe Zhang et al. (2012) used a push-pull forward half bridge circuit and a high frequency transformer to construct the converter. The number of switching transistors and gate driver components required in this design has been reduced. Phase shift control schemes require all switches to function at zero volts. There were many considerations, such as flow analysis and harmonics analysis, that they looked into to improve the converter's performance and raise its efficiency.

Mariodi Bernardo et al. (1998) investigated nonlinear effects in closed loop pulse width modulated DC-DC converters. Analytic conditions for periodic orbits and flip bifurcations as well as conditions for local stretching on the phase plane were derived from these discoveries, according to the authors of this study.

III PHOTOVOLTAIC TECHNOLOGY

An area of photovoltaics that deals with the use of photovoltaic semiconductors to directly convert sunlight into electricity is known as this particular subfield. The photovoltaic effect occurs when a material is subjected to electromagnetic radiation, which generates voltage. It was French physicist Edmund Becquerel's discovery of the photovoltaic effect that led to the development of the photovoltaic cell. On the nature of light and the photoelectric effect, Albert Einstein earned the Nobel Prize in physics in 1905. This is the cornerstone for photovoltaic technology The first solar module was developed at Bell Laboratories in 1954. Although it was billed as a solar battery, its high price made it more of a museum piece than anything else. NASA's space industry began using energy on board spacecraft in earnest in the 1960s. During the course of the space programmes, a great deal of progress was made in terms of technology and reliability. During the 1970s energy crisis, it became evident that photovoltaic technology might be utilised for more than only space flight. The solar cell is the building block of a photovoltaic system. Solar cells use semiconductors, such as silicon. Impurities introduced into the crystal lattice of semiconductors have the power to modify conductivity, making them immensely important. When producing a photovoltaic solar cell, for example, silicon, which has four valence electrons, is treated to increase its conductivity. One of the reasons for excess negative charge carriers is the presence of impurities, such as 5-valence-electrons phosphorus atoms (n-donor). Its is due to the fact that boron has three p-donors, which makes it more receptive to electrons than other crystals of this type. It's because the p-type silicon is so close to the n-type silicon that an electron diffusion from the high electron concentration side to the low electron concentration side occurs, and this results in a p-n junction (p-type side). They merge with holes on the p-type side of the junction as they expand out. However, the dispersion of carriers does not continue indefinitely since an electric field is formed instantly on either side of the junction by the charge imbalance. Electricity can only flow in one direction because of the diode created by the electric field. The electrodes on the n- and p-type solar cells have been connected to an external load via ohmic metal-semiconductor connections. Photons of light fall on the cell and provide energy to charge carriers. Photo-generated positive charge carriers (holes) are separated from their corresponding negative charge carriers by the electric field across the junction (electrons). If a circuit is closed, an external load will draw an electrical current.

A. The solar panel Design

With Edmund Becquerel's discovery in 1839, light striking a silver-coated platinum electrode submerged in electrolyte yielded the photovoltaic effect for the first time. The first solid-state photovoltaic systems were constructed forty years after researchers discovered selenium's newly discovered photoconductivity. Photovoltaic cells were invented after William Adams and Richard Day discovered that heated platinum contacts could generate a photocurrent in a sample of selenium. The selenium's photovoltaic rather than photoconductive capabilities spontaneously generated a current.

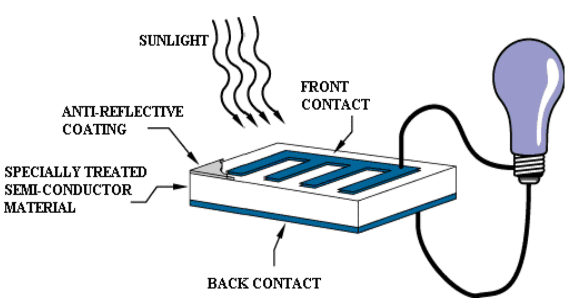


Figure 1 Solar cell.

An external power source was not required. In this early solar device, a rectifying junction had formed between the semiconductor and the metal contact. Charles Fritts constructed what is possibly the first large-area solar cell in 1894 by compressing a covering of selenium between a layer of gold and another metal.

Copper-copper oxide thin-lm frameworks and systems with additional lead and thallium were found to exhibit photovoltaic effects in the following years. In the earliest cells, which were thin film Schottky barrier devices, a semi-transparent metal layer placed on top of a semiconductor provided both the asymmetric electronic junction required for photovoltaic activity and access for incident light to the junction. These devices' photovoltaic effect was explained by Goldman and Brodsky in 1914, who related the current flow barrier at one of the semiconductor metal contacts to the effect (i.e. rectifying action) Metal-semiconductor barrier layers were the subject of theoretical development in the 1930s by Walter Schottky, Neville Mott, and other researchers.

Instead of their photovoltaic properties, minerals like selenium first piqued researchers' interest due to their photoconductivity. It was found that photoconductive materials were ideal for use as photographic light metres since the generated current was inversely proportional to incident light intensity and directly connected to wavelength. Having the light metre powered by photovoltaics was an added plus. A large amount of electricity was generated by photovoltaic devices made of crystalline silicon in the 1950s, when high-quality silicon wafers for use in solid-state electronics were produced.

B. PV system design

Systems can be set up in a variety of ways, the two most common being standalone and grid-connected. A stand-alone PV system may provide power to multiple loads without relying on any other power source. It is possible to create power at night or when there is inadequate sunshine if a storage facility (like a battery bank) is available to store energy. Separate systems are sometimes known as autonomous systems because they do not require external power sources to function. In contrast, grid-connected photovoltaic (PV) systems operate independently of the main electrical grid. The grid distribution system or loads that can also be supplied by the grid can receive electricity.

The system can be supplemented by one or more different power sources to meet some of the load requirements (such as a diesel engine or a wind turbine). The term "hybrid" is used in the industry to describe this type of technology.

Hybrid systems can be used in both stand-alone and grid-connected applications as long as the power supplies are complementary, but they are more common in the former because they minimise storage requirements while keeping the same load probability. Following are the schematic diagrams for each of the three basic system kinds.

IV MODULAR MULTILEVEL CONVERTERS

Increasing human energy consumption necessitates the installation of extra high voltage power lines with high power transmission capabilities in order to keep pace with the rising demand. This demonstrates the importance of designing high-voltage power lines and accompanying equipment to be as efficient as possible in terms of cost, ripple, harmonics, and switching losses. Pulse width modulation (PWM) is accessible in a variety of forms. It is necessary to do comprehensive research on the associated equipment, such as converter station devices, in order to switch the high voltage and high power lines in order to fulfil the rising demand for electric power. Particular attention is needed to the design of three-phase inverter bridge circuits in order to minimise harmonic and switching losses. Varied multilevel converters with various control strategies are available elsewhere in the world to get required efficiency outputs [5]- [11]. DC/AC, DC/DC, AC/DC, and AC/AC power converters are commonly used in a variety of applications, including high-voltage direct current (HVDC) transmission systems and energy storage systems, solar photovoltaic (PV) battery energy storage systems, and active power filters (APFs) (PET). When a sufficient number of modules are employed, the converter switching errors are reduced and the module switching frequency is reduced[16]. Some applications of multilevel converters use both voltage and current source converters, while others use only one type of converter at a time. [12]-[18] various topologies are employed to eliminate harmonic distortions and total voltage ripples in output voltages and currents.. It is common practise in other countries to create and use a variety of topologies, such as the neutral point clamped kind of converter, the flying capacitor kind of converter, the cascaded H-bridge, and the modular multilevel converter (MMC). Each converter topology has its own advantages and disadvantages when compared to the other options. " These converters are ideally suited for output voltage waves with lower stress and lower harmonic content [23]-[27]. CHB, on the other hand, continues to advocate for establishing a separate, constant DC supply for each of the bridge's arms. However, because of phase-shifting transformers, isolation transformers, and the like, all of these converters can only be used in high-power voltage driving applications.

Using MMC in a wide range of applications, such as extended high voltage and power, large-scale industries and more, as demonstrated in figure 11. HV/EHV transmission systems, in particular, benefit from MMC's design considerations because of their high voltage and power requirements.

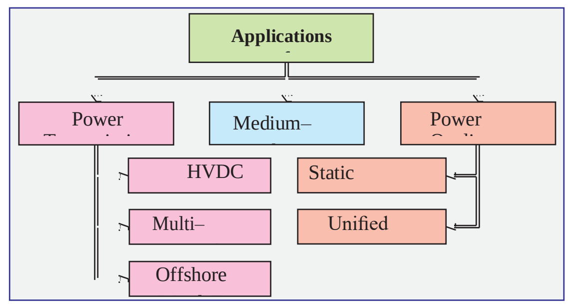


Figure 2 Applications of MMC

A. *Proposed Controllers*

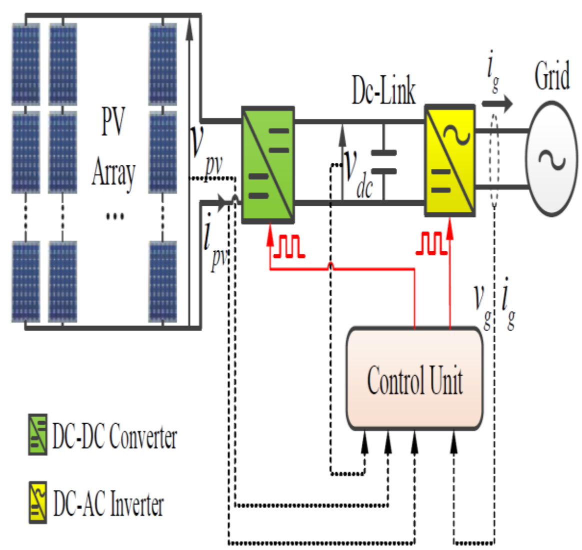


Figure 3 Grid-tethered home PV system configuration

The grid voltage and current are represented by vg and igre, whereas the output voltage and current of the PV array are represented by vpvand ipvare. Vdc denotes the DC-link voltage. In the first place, there are solar panels that generate electricity through the process of photovoltaics. Solar cells are frequently linked in series in PV panels, which provide a standard DC voltage. There are numerous arrays of photovoltaic (PV) panels used to create the required voltage and current. Temperature and irradiance both have an impact on the electricity generated by photovoltaic modules. Continuous monitoring of the MPP of a PV system is essential to maximising its output power. The DC-DC converter that connects the PV array to the DC link capacitor can be adjusted to accomplish this.

B. The Network Control Of Three-Phase Solar Inverter

To put it another way, an ANN is a computer software that attempts to simulate the learning process of a biological neural network. Machine learning and pattern recognition are both possible with ANNs. The network's distributed parallel structure allows these "neurons" to compute values from inputs [17]. In Figure, an artificial neural network is depicted as a schematic.

ANNs can increase their overall performance by absorbing information from their environment. Artificial neural networks (ANNs) can be used to approximate any function by "learning" from previous data sets.

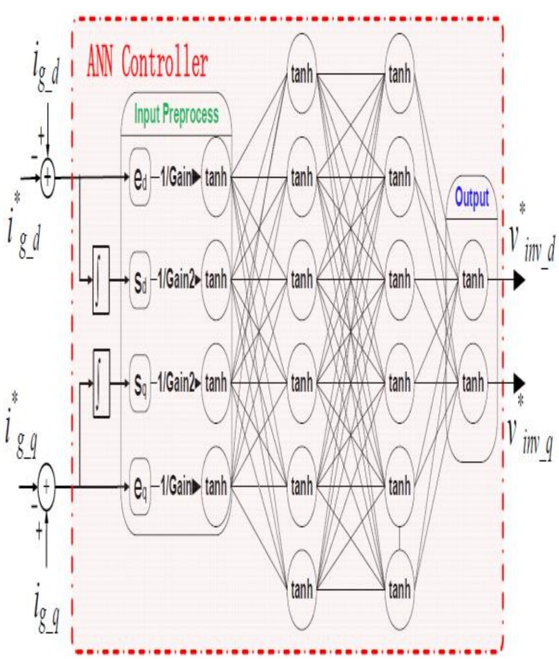
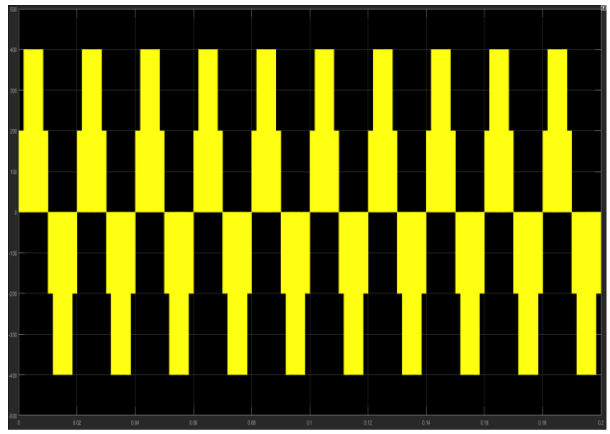
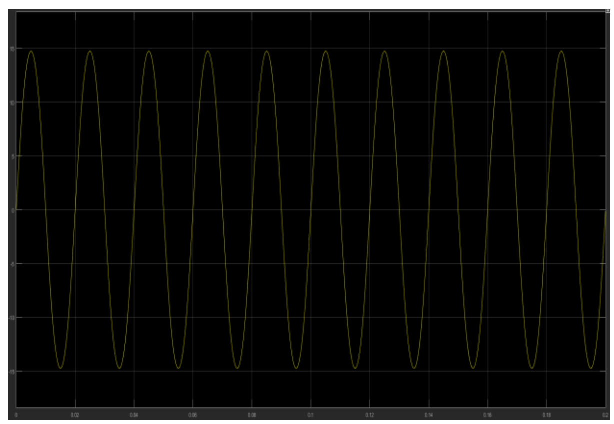


Figure 4 Neural network current-loop vector control

To supplement the previous section's investigation of the switching function, the proposed five-level CMLI is simulated in MATLAB/SIMULINK using POWERSIM blocks. It was determined that independent feedforward compensation for each arm of the MMC submodule was beneficial. DClink voltages begin to shift from zero to a new equilibrium point as a result of marginal progress stability, as illustrated in the findings of the prior analysis using independent feed forward compensation.



(a)



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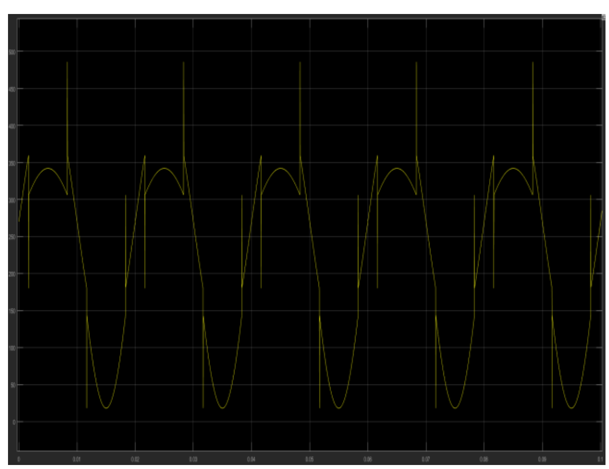
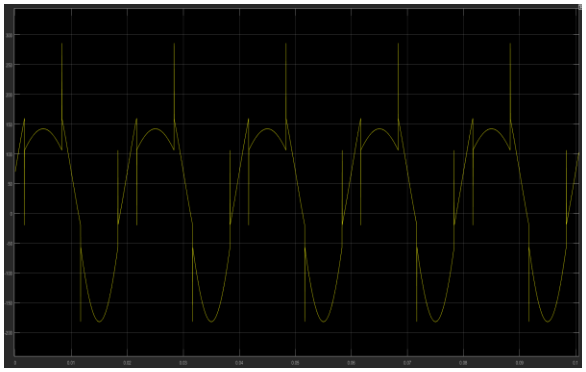


(c)



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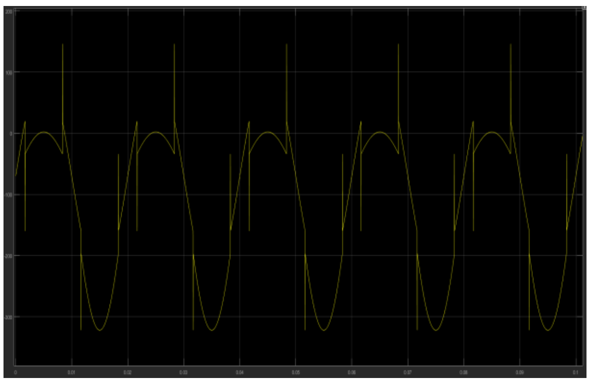

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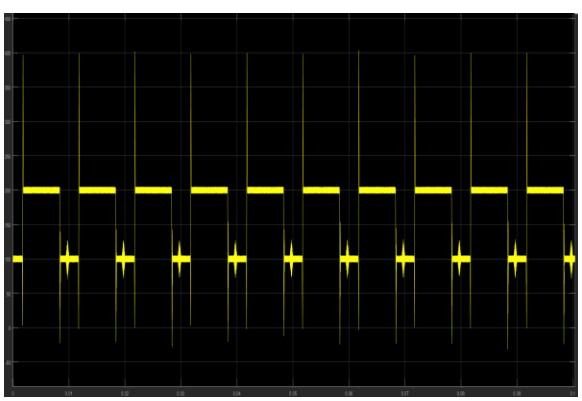
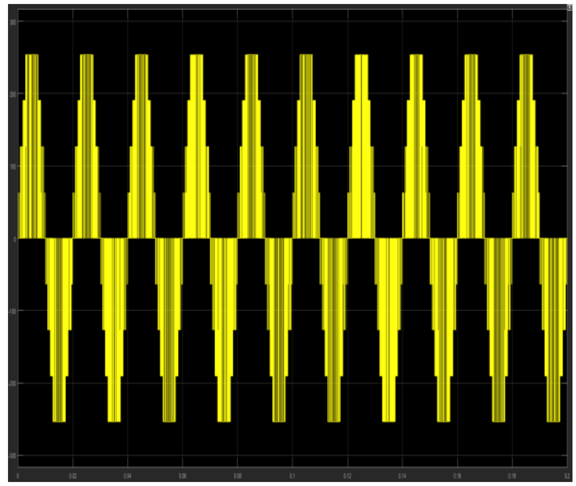


(g)



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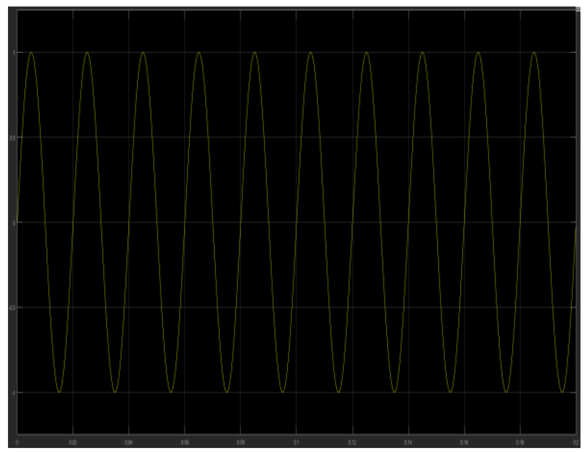

(i)

Figure 5 Simulation results of the proposed Five-Level MMC showing the wavwforms of output voltage ,Grid current,Terminal voltage,Leakage currents

CONCLUSION

This study offers a five-level, low-switch-count MMC to reduce leakage current in a transformer less PV system. A modular multilevel inverter is used to compensate for the dc link voltage in this work. The MMC is programmed using an ANN logic controller in this project. For systems with fundamental AC output frequency changes, the suggested ANN controller achieves a significantly improved transient response and a wider frequency band response. In order to acquire weighing components using conventional approaches, the process is a lengthy and repetitive one. Consequently, non-parametric optimization of MMC's intricate internal properties is addressed in this article. Two-phase-to-ground grid faults have been tested, but this technology can be used to other unbalanced grid circumstances as well. ANN methods for DC circulating current component optimization will be explored in future studies.

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