

## A Review on Multilevel Inverters with Machine Learning Techniques

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### **ABSTRACT**

*Multilevel inverters have appeared as a promising technology for high-power and high-voltage applications due to their capability to produce higher-quality output waveforms with reduced harmonic distortion and improved power quality. However, to fully exploit the potential of multilevel inverters, advanced control strategies and intelligent decision-making are required to optimize their performance and efficiency under various operating conditions. Machine learning techniques have proven to be instrumental in achieving these goals. It highlights the various machine learning applications in multilevel inverters, focusing on their role in enhancing performance and control. By leveraging data-driven insights, machine learning algorithms optimize the switching strategies, modulation indices, and control parameters to minimize harmonic distortions, improve energy conversion efficiency and reduce electromagnetic interference (EMI). Additionally, predictive maintenance models based on machine learning allow for the early detection of potential faults, leading to proactive maintenance and improved system reliability. Furthermore, machine learning enables multilevel inverters to become adaptive and self-learning systems. Through continuous learning from historical data and real-time measurements, these inverters can dynamically adjust their control strategies to adapt to changing load demands and operating conditions, ensuring efficient power flow and stable grid integration. It also discusses the advantages of using machine learning in multilevel inverters, such as improved output waveform quality, higher voltage capability, reduced switching losses, and increased fault tolerance. These advantages position multilevel inverters as a compelling choice for various applications, including renewable energy systems, industrial processes, smart grid integration, and electric vehicle charging. Overall, the application of machine learning in multilevel inverters empowers these power conversion systems with intelligence, adaptability, and efficiency, making them more suitable for addressing the evolving challenges of modern power distribution and utilization. As machine learning techniques continue to evolve, their integration with multilevel inverters is expected to unlock further advancements in power conversion technologies and drive the transition towards a more sustainable and reliable energy landscape.*

**Keywords:** Machine learning (ML), Multilevel Inverter (MLI)

### **INTRODUCTION[1-5]**

An inverter is an electronic gadget that converts direct current (DC) electricity into alternating current (AC) electricity. In other words, it takes the electricity generated from batteries, solar panels, or other DC sources and transforms it into the

AC electricity needed to power most household appliances and electrical devices. The main purpose of an inverter is to provide a reliable source of AC power when there is no direct grid connection or when AC power is not available. Here are some common uses of inverters:

### Backup Power Supply

Inverters are often used as backup power supplies during power outages. They can be connected to batteries, which store DC power, and when the main power supply fails, the inverter switches on and converts the DC power from the batteries into AC power to keep essential appliances and devices running.

### Renewable Energy Systems

Inverters play a crucial role in renewable energy systems like solar and wind power. Solar panels and wind turbines generate DC power, which needs to be converted into AC power before it can be used to power homes and businesses or be fed back into the electrical grid.

### RVs and Boats

Inverters are commonly used in recreational vehicles (RVs) and boats to convert the DC power from batteries into AC power, allowing occupants to use household appliances and electronics while on the move or when docked without access to external power sources.

### Remote Locations

In remote locations where access to the main electrical grid is limited or not possible, inverters enable the use of electrical devices and equipment powered by DC sources like generators or batteries.

### Portable Power Supplies

Portable inverters are widely used to charge electronic devices such as laptops, smartphones, and cameras when traditional AC power outlets are not available. These inverters can be powered by a vehicle's DC outlet or batteries.

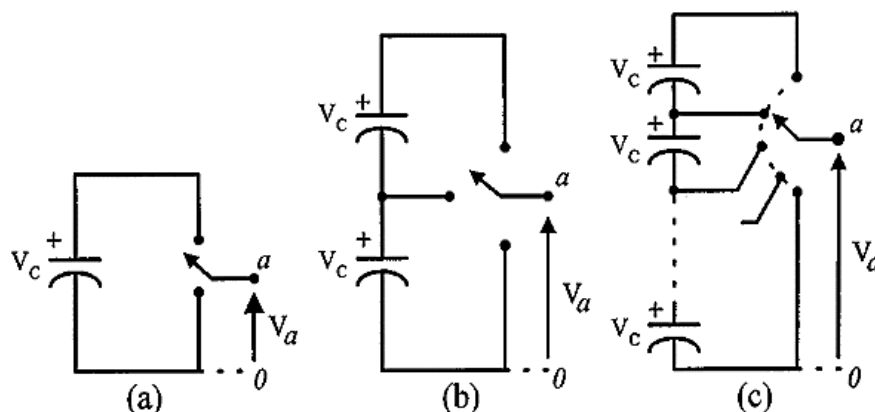
### Industrial Applications

In industrial settings, inverters are used to control the speed and torque of AC motors. This allows for efficient and variable speed operation, which can save energy and optimize processes in various applications.

### Microgrids

Inverters are an essential component of microgrids, which are small-scale power systems that can function independently or in conjunction with the chief electrical grid. They help manage the flow of power between various energy sources and loads in the microgrid.

It's fundamental to take note of that inverters come in various kinds, for example, unadulterated sine wave inverters (delivering a smooth waveform like grid power) and changed sine wave inverters (creating a harsh estimation of a sine wave). The type of inverter used depends on the specific application and the sensitivity of the connected devices to the quality of the AC waveform.



*Fig. 1: Types of Multilevel Inverters.*

**DISADVANTAGES OF INVERTER  
[6-8]**

Inverters, like any other electronic device, have their disadvantages. Some of the common disadvantages of inverters include:

**Energy Losses**

In the process of converting DC power to AC power, inverters incur some energy losses. These losses are due to switching inefficiencies, semiconductor losses, and other internal resistances. As a result, the output power of the inverter is slightly lower than the input power.

**Harmonic Distortion**

Inverters can introduce harmonic distortion into the AC output waveform. Harmonics are frequencies that are products of the fundamental recurrence (50 or 60 Hz). Excessive harmonic distortion can lead to interference with other electronic devices, reduced efficiency in electrical systems, and additional heating of electrical equipment.

**Electromagnetic Interference (EMI)**

Inverters can generate electromagnetic interference, which can affect nearby electronic devices and communication systems. EMI can lead to malfunctions, data errors, or interference with radio and TV signals.

**Voltage Fluctuations and Instability**

Some cheaper or poorly designed inverters may produce AC output with voltage fluctuations and instability. This can lead to unreliable operation of electrical devices and may even damage sensitive equipment.

**Complexity and Maintenance**

Certain types of inverters, such as multilevel inverters, can be complex in their circuitry and control systems. This complexity can make maintenance and

troubleshooting more challenging, requiring skilled technicians for repairs.

**Efficiency Variation**

The efficiency of an inverter can vary depending on the load it is driving. Inverters may have lower efficiency at lighter loads compared to their peak efficiency at moderate to heavy loads. This can impact energy consumption and overall system efficiency.

**Electro-Mechanical Interference**

In some cases, inverters can cause vibrations or acoustic noise due to the rapid switching of internal components. This can be a concern in certain applications, such as in residential settings where noise can be disruptive.

**Component Reliability**

The reliability of an inverter largely depends on the quality of its components and design. Cheaper or poorly constructed inverters may have lower component lifespans, leading to more frequent failures and replacements.

Despite these disadvantages, inverters remain essential devices for various applications, including renewable energy systems, backup power supplies, and many other areas where DC to AC power conversion is required. Proper selection, installation, and maintenance can help mitigate some of the drawbacks associated with inverters.

**NECESSITY OF MULTILEVEL  
INVERTERS[9,10]**

Multilevel inverters are necessary and advantageous in various applications due to the following reasons:

**Improved Output Waveform**

Multilevel inverters produce output waveforms with reduced harmonic distortion compared to conventional two-level inverters. This is particularly

important in applications where high-quality AC power is required, such as in sensitive electronic devices, motor drives, and certain industrial processes.

**Higher Voltage Output**

Multilevel inverters can generate higher voltage output without requiring excessively high voltage-rated switching components. This is beneficial in applications like high-power motor drives, renewable energy systems, and grid interconnection, where higher voltage levels are necessary.

**Reduced Electromagnetic Interference (EMI)**

The lower harmonic content in the output waveform of multilevel inverters results in reduced electromagnetic interference. This makes them suitable for applications where minimizing EMI is crucial, such as in telecommunications, data centers, and radio frequency-sensitive environments.

**Lower Switching Losses**

Multilevel inverters distribute the voltage across multiple levels, reducing the voltage stress on each switching device. As a result, they experience lower switching losses compared to conventional inverters, leading to improved overall efficiency.

**High-Voltage DC Transmission (HVDC)**

In HVDC transmission systems, multilevel inverters are used to convert DC power

from renewable energy sources or long-distance transmission lines into AC power for distribution. They allow for efficient power transmission over long distances with reduced losses and better voltage control.

**Grid Integration of Renewable Energy**

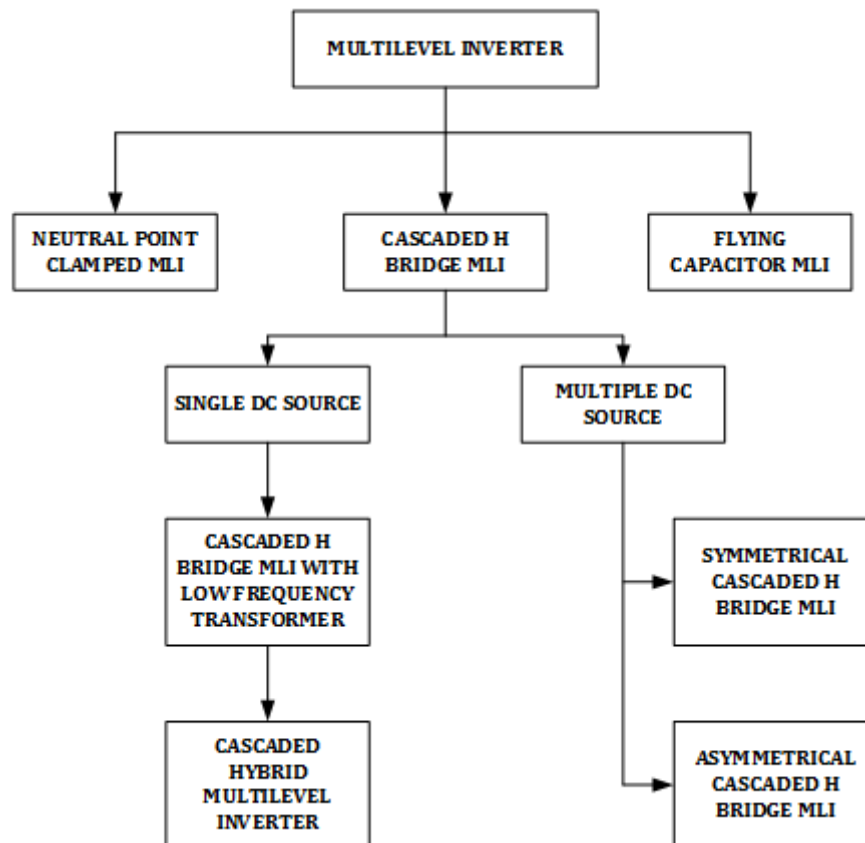
In renewable energy systems like solar and wind power, multilevel inverters are employed to convert DC power generated by solar panels or wind turbines into grid-compliant AC power. They help improve grid stability and facilitate smooth integration of renewable energy sources into the power grid.

**Motor Drives**

In high-power motor drive applications, multilevel inverters enable better control of motor speed and torque, leading to improved efficiency and reduced motor heating. This is especially advantageous in industrial processes and electric transportation systems.

**Power Quality Improvement**

Multilevel inverters can be utilized in power conditioning systems to improve the quality of electrical power by compensating for voltage sags, swells, and other power disturbances. This enhances the reliability of sensitive equipment and processes.



*Fig. 2: Types of Multilevel Inverters.*

Multilevel inverters offer a few benefits over ordinary two-level inverters, making them suitable for various high-power and high-voltage applications. Here are some key advantages of multilevel inverters:

#### **Improved Output Waveform Quality**

Multilevel inverters produce higher-quality output waveforms compared to two-level inverters. The multilevel structure allows for more voltage levels, reducing harmonic distortion and improving power quality. This makes them well-suited for applications where clean and smooth AC power is essential.

#### **Reduced Electromagnetic Interference (EMI)**

Due to their improved output waveform quality, multilevel inverters produce lower EMI compared to conventional inverters. This is especially important in applications sensitive to electromagnetic interference,

such as telecommunication systems, data centers, and medical devices.

#### **Higher Voltage Capability**

Multilevel inverters can generate higher voltage levels without requiring excessively high voltage-rated switching components. This makes them suitable for high-voltage applications, such as renewable energy systems, high-power motor drives, and HVDC transmission.

#### **Lower Total Harmonic Distortion (THD)**

Multilevel inverters inherently have lower THD in their output voltage, reducing stress on electrical equipment and increasing the efficiency of connected devices.

#### **Reduced Switching Losses**

Multilevel inverters distribute the voltage across multiple levels, resulting in lower

voltage stress on each switching device. This leads to reduced switching losses and improved overall efficiency compared to conventional inverters.

**Lower Electromechanical Stress**

The reduced switching frequency and improved output waveform of multilevel inverters result in lower stress on connected motors and electrical components, leading to longer equipment lifespan and reduced maintenance costs.

**High Efficiency at Partial Loads**

Multilevel inverters can maintain high efficiency even at partial load conditions, making them suitable for applications with varying load demands.

**Modular Design and Scalability**

Multilevel inverters can be designed in a modular fashion, making them easier to scale up for higher power requirements. The addition of more voltage levels allows for increased power handling capabilities.

**Fault Tolerance**

Multilevel inverters have inherent fault tolerance capabilities due to their redundant voltage levels. Even if one or more levels fail, the inverter can continue to operate at reduced capacity.

**High-Power Applications**

Multilevel inverters are particularly advantageous in high-power applications, such as grid-connected renewable energy systems, high-voltage motor drives, electric vehicles, and industrial processes.

Due to these advantages, multilevel inverters are turning out to be progressively famous in different enterprises where high-power, great AC power and productive voltage change are critical prerequisites. Their ability to deliver cleaner power, higher voltage capability, and improved efficiency makes

them an attractive choice for modern power conversion applications.

**CASCADED MLI**

Cascaded multilevel inverter sometimes referred to as a H-bridge inverter connected in series. In 1975, the introduction of the series H-bridge inverter taken place. It took two researchers, Lai and Peng, to properly create the cascaded multilayer inverter. In 1997, they highlighted its multiple benefits and obtained a patent for it. Since then, a variety of applications have made use of the CMI. The CMI excels in high-power applications thanks to its versatility and adaptability, particularly with shunt and series coupled FACTS controllers. By mixing numerous independent voltage levels, the CMI creates voltage waveforms that are almost sinusoidal in their output. An H-bridge converter series-chain with three identical phase legs is the basis of a three-phase CMI architecture that has the capacity to phase-balance an AC unit and produce dissimilar output voltage waveforms.

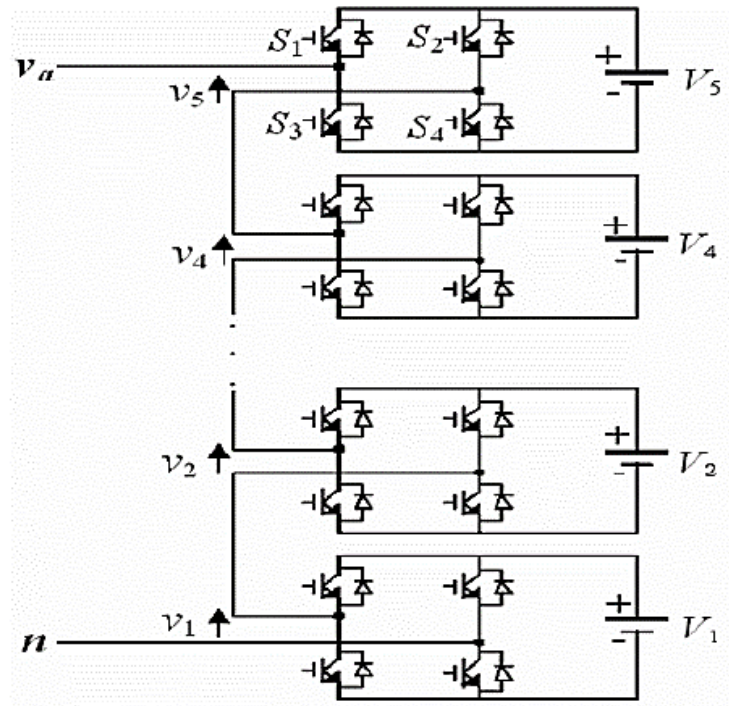
It seems suitable to talk about the difference among "multilevel converter" and "multilevel inverter" at this time. The converter itself is referred to as a "multilevel converter". The phrase also implies that power can be used in one of two ways. Power can be moved from the ac side to dc side using the MLC. The rectification mode of operation is the name given to this style of operation.

The multilevel converter's dc side and ac side can both receive power. The inverting mode of operation is the name given to this line of action. Employing a multilayer conversion in its inverting operation mode is referred to as using a "multilevel inverter." A multilayer inverter's primary job is to renovate different dc voltage levels into the correct ac voltage waveform. There is a chance that these DC



voltages are equivalent. These dc voltages generate an ac voltage that nearly

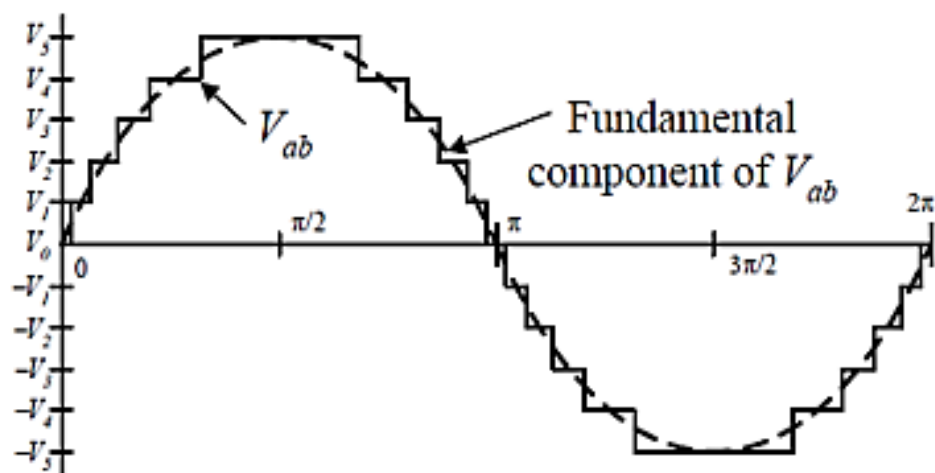
resembles a sinusoid.[11]



**Fig. 3:** Cascaded Multilevel Inverter.

A sinusoidal waveform comes close to being produced by the multilevel inverter. As more DC sources are added, this estimate will become more precise. The staircase waveform must ideally grow closer to the necessary sinusoid as the dc sources quantity tactics infinity. All

techniques of switching that can be applied to a multilayer inverter do not always result in a staircase waveform. PWM (Virtual Stage), PWM (Bipolar Programmed), as well as PWM(Unipolar Programmed) are a few examples.



**Fig. 4:** Output waveform of Multilevel Inverter.

**WHY CASCADED H-BRIDGE MLI?**

The use of cascading H-Bridges (CHB) architecture has significantly increased nowadays many applications are requiring AC supplies of high power besides variable-speed drives. A cascade MLI contains three phases, each of which is formed up of a series of units of H-bridge units. The unique dc supply for each H-bridge unit would be provided by a battery system, fuel cell, or solar cell in the case of an induction motor. A different D.C. source is linked to each full-bridge inverter of single-phase (SDC). The terminal voltages of ac of various inverter levels are connected in series. By combining the 4 switches S1 through S4, every converter level can create one of 3 outputs of voltage: plus, minus, or zero.

The outcomes of every converter are additional together to create the voltage waveform by connecting the outputs of several converters of full bridge running in the similar phase in series. Remembering the quantity of output-phase voltage levels is demarcated differently than it was for the two preceding converters (i.e. DCMLI as well as FCMLI). The formula  $m=2N+1$ , where N is the total number of DC sources, determines the amount of voltage levels in this design.

The three complete bridge converters & three DC sources make up a seven-level cascaded converter, for instance. By adjusting the conducting angles at various converter levels, the least amount of THD can be achieved. By altering the timing of the positively and negatively phase legs of every H-bridge unit, a quasi-square waveform is created. The current load on all switching devices is equal with this switching strategy.

In the motoring phase, a cascaded inverter transmits power from the batteries to the load. The 180° conducting technique as well as the pattern-swapping system work

together to ensure that the voltage as well as current loads on the CHBI are the same and that the battery voltage is balanced.

Utilizing units of H-bridge which are identical improves flexibility as well as lowers the production costs. A prototype battery-fed CHBMLI voltage as well as current are sinusoidal almost, while load of induction motor is running at 50% besides 80% of its rated speed. The sinusoidal voltage output and low dv/dt result in substantially reduced EMI and common mode voltage than a PWM inverter would provide.[12]

**MACHINE LEARNING**

Machine learning is a subfield of artificial intelligence (AI) that spotlights on the improvement of calculations and factual models that empower PCs to gain from and settle on expectations or choices in view of information, without being expressly customized for explicit undertakings. The primary goal of machine learning is to enable computers to learn and improve their performance over time through experience.

The process of machine learning typically involves the following steps:

**Data Collection**

The first step in machine learning is gathering relevant data related to the problem at hand. This data can include examples, measurements, observations, or any other information that represents the problem domain.

**Data Pre-processing**

Once the data is collected, it often needs to be pre-processed to remove noise, handle missing values, normalize or scale the data, and make it suitable for training machine learning algorithms.

**Feature Extraction/Selection**

In some cases, the raw data may contain irrelevant or redundant features. Feature



extraction or selection techniques are used to identify and retain the most relevant information for the learning process.

### Training Data and Testing Data

The dataset is divided into two parts: the training set, which is used to train the machine learning model, and the testing set, which is used to evaluate the model's performance.

### Choosing a Model

Machine learning algorithms come in different kinds, like administered learning, unaided learning, and support learning. The decision of the suitable calculation relies upon the sort of issue and the idea of the information.

### Training the Model

During the training phase, the machine learning model is exposed to the training data, and it learns to recognize patterns, correlations, or relationships within the data.

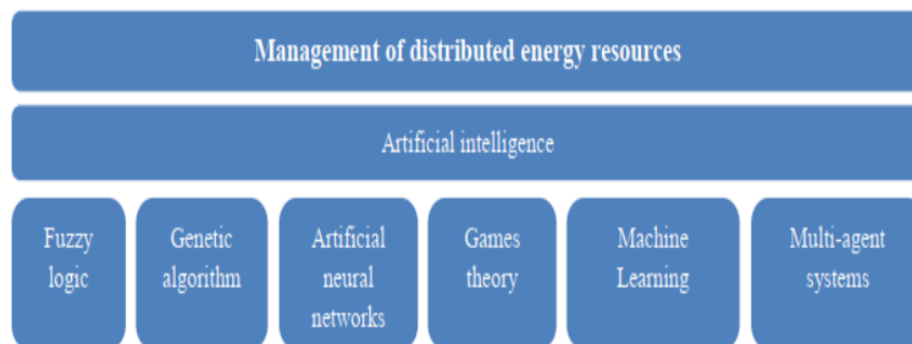
### Model Evaluation

After training, the model is evaluated using the testing set to assess its performance and generalization capabilities. The model's ability to make accurate predictions on new, unseen data is crucial for its effectiveness.

### Model Deployment

Once the model is trained and evaluated satisfactorily, it can be deployed to make predictions or decisions on new data in real-world applications.

Machine learning is used in a large number of utilizations, including picture and discourse acknowledgment, normal language handling, suggestion frameworks, independent vehicles, clinical determination, monetary examination, and significantly more. It has become an essential tool in the field of AI, enabling systems to adapt and improve their performance based on the data they encounter.



**Fig. 5:** ML in management of DES.

### HOW ML IS USED IN MLI?

Machine learning can be used in various ways to enhance the performance, efficiency, and control of multilevel inverters. Here are some ways in which machine learning is applied in multilevel inverters:

**Fault Detection and Diagnosis**  
Machine learning algorithms can be used

to monitor the operation of the multilevel inverter and detect any faults or anomalies in real-time. By analyzing the voltage and current waveforms and comparing them to normal operation patterns, the system can identify potential issues early, allowing for timely maintenance or system shutdown to prevent further damage.

**Optimized Control Strategies**

Machine learning techniques can be employed to develop optimized control strategies for multilevel inverters. These strategies can be adaptive and self-adjusting, taking into account various operating conditions and load demands to maximize efficiency and minimize harmonic distortions.

**Load Prediction and Balancing**

Machine learning models can predict the load requirements of a multilevel inverter system based on historical data and real-time measurements. This allows for proactive load balancing and distribution among the different levels of the inverter, ensuring efficient use of resources and minimizing stress on individual components.

**Harmonic Elimination and Control**

Machine learning algorithms can be utilized to intelligently control the switching patterns of the multilevel inverter to reduce harmonic distortions in the output waveform. By learning from past performance and real-time data, the system can optimize the switching frequencies and patterns for better power quality.

**Efficiency Improvement**

Machine learning can aid in optimizing the efficiency of multilevel inverters by adjusting parameters like modulation index, carrier frequency, and control signals based on the operating conditions and load demands. This can lead to energy savings and reduced losses in the inverter system.

**Predictive Maintenance**

By analyzing sensor data and historical performance, machine learning can predict the health and remaining useful life of critical components in the multilevel inverter. Predictive maintenance can reduce downtime and maintenance costs

by allowing timely replacement or repair of components before they fail.

**Smart Grid Integration**

Machine learning algorithms can be used to enhance the integration of multilevel inverters with smart grids. They can analyze grid conditions, demand patterns, and renewable energy availability to optimize the operation of the inverter system, ensuring efficient power flow and grid stability.

Overall, the combination of machine learning and multilevel inverters can lead to more efficient, reliable, and intelligent power conversion systems. As machine learning techniques continue to advance, their integration with multilevel inverters is likely to yield even more significant benefits in various applications and industries.

**ML IN MLI**

Machine learning is used in multilevel inverters to improve their performance, efficiency, and control by leveraging the power of data-driven insights. Here are the key purposes and benefits of using machine learning in multilevel inverters:[13]

**Optimized Control Strategies**

Machine learning algorithms can develop advanced control strategies for multilevel inverters that adapt to changing operating conditions and load demands. These strategies can optimize the switching patterns, modulation index, and other control parameters to achieve improved efficiency and minimize harmonic distortions.

**Load Prediction and Balancing**

By analyzing historical data and real-time measurements, machine learning can predict load requirements and distribute the load intelligently among the different levels of the multilevel inverter. This

ensures that the system operates efficiently and avoids overloading specific components.

### **Harmonic Elimination and Power Quality Improvement**

Machine learning techniques can help minimize harmonic distortions in the output waveform of the multilevel inverter. By learning from data and historical performance, the system can optimize the switching frequencies and patterns to enhance power quality.

### **Fault Detection and Diagnostics**

Machine learning algorithms can monitor the operation of the multilevel inverter and detect any faults or anomalies in real-time. This enables proactive maintenance and prevents further damage to the system.

### **Efficiency Enhancement**

Machine learning can optimize the efficiency of multilevel inverters by adjusting control parameters based on real-time data and load conditions. This leads to energy savings and reduced losses in the system.

### **Predictive Maintenance**

Machine learning can predict the health and remaining useful life of critical components in the multilevel inverter, enabling predictive maintenance. Timely replacement or repair of components before failure reduces downtime and maintenance costs.

### **Smart Grid Integration**

Machine learning can optimize the integration of multilevel inverters with smart grids by analyzing grid conditions, demand patterns, and renewable energy availability. This ensures efficient power flow and grid stability.

### **Adaptive and Self-Learning Systems**

Machine learning allows multilevel inverters to become adaptive and self-

learning. They can continuously improve their performance over time by learning from data and adjusting their operation accordingly.

### **Customization to Specific Applications**

Machine learning enables multilevel inverters to be customized and optimized for specific applications and operating conditions, leading to better performance and reliability.

Overall, the application of machine learning in multilevel inverters empowers these power conversion systems with intelligence, flexibility, and efficiency, making them more suitable for a wide range of applications, including renewable energy integration, industrial processes, smart grids, and more.

### **CONCLUSION**

Machine Learning has emerged as a powerful tool in optimizing the performance and control of multilevel inverters. By leveraging data-driven insights and adaptive decision-making, machine learning algorithms enhance the efficiency, reliability and power quality of these advanced power conversion systems. The applications of machine learning in multilevel inverters encompass a wide range of functionalities, from optimizing switching strategies and modulation indices to predicting load demands and detecting potential faults. Through continuous learning and real-time adjustments, multilevel inverters can adapt to changing operating conditions and load demands, making them more efficient and reliable in various high-power and high-voltage applications. The advantages of machine learning in multilevel inverters, such as improved output waveform quality, reduced harmonic distortion, and lower electromagnetic interference, position them as a compelling choice for critical applications in industrial processes, renewable energy integration, smart grid

integration, electric vehicles, and more. The potential for machine learning in multilevel inverters is still expanding as research and development in both fields progress. Further advancements in machine learning algorithms and data-driven control strategies are expected to unlock even more opportunities for optimizing multilevel inverter systems. As we continue to address the challenges of a rapidly evolving energy landscape, the synergy between machine learning and multilevel inverters plays a vital role in achieving cleaner, more efficient, and sustainable power conversion technologies. By combining the intelligence of machine learning with the capabilities of multilevel inverters, we move closer to a future where power systems are smarter, more adaptive, and better equipped to meet the demands of growing global energy consumption.

## REFERENCES

1. Adel, T., Valera, I., Ghahramani, Z., & Weller, A. (2019, July). One-network adversarial fairness. In *Proceedings of the AAAI Conference on Artificial Intelligence* (Vol. 33, No. 01, pp. 2412-2420).
2. Ali, S. M., & Silvey, S. D. (1966). A general class of coefficients of divergence of one distribution from another. *Journal of the Royal Statistical Society: Series B (Methodological)*, 28(1), 131-142.
3. Barocas, S., & Selbst, A. D. (2016). Big data's disparate impact. *California law review*, 671-732.
4. Berk, R., Heidari, H., Jabbari, S., Kearns, M., & Roth, A. (2021). Fairness in criminal justice risk assessments: The state of the art. *Sociological Methods & Research*, 50(1), 3-44.
5. Beutel, A., Chen, J., Zhao, Z., & Chi, E. H. (2017). Data decisions and theoretical implications when adversarially learning fair representations. *arXiv preprint arXiv:1707.00075*.
6. Blum, A., & Stangl, K. (2019). Recovering from biased data: Can fairness constraints improve accuracy?. *arXiv preprint arXiv:1912.01094*.
7. Buolamwini, J., & Gebru, T. (2018, January). Gender shades: Intersectional accuracy disparities in commercial gender classification. In *Conference on fairness, accountability and transparency* (pp. 77-91). PMLR.
8. Calders, T., Kamiran, F., & Pechenizkiy, M. (2009, December). Building classifiers with independency constraints. In *2009 IEEE international conference on data mining workshops* (pp. 13-18). IEEE.
9. Chi, J., Tian, Y., Gordon, G. J., & Zhao, H. (2021, July). Understanding and mitigating accuracy disparity in regression. In *International conference on machine learning* (pp. 1866-1876). PMLR.
10. Chouldechova, A. (2017). Fair prediction with disparate impact: A study of bias in recidivism prediction instruments. *Big data*, 5(2), 153-163.
11. Chzheng, E., Denis, C., Hebiri, M., Oneto, L., & Pontil, M. (2020). Fair regression with wasserstein barycenters. *Advances in Neural Information Processing Systems*, 33, 7321-7331.
12. Corbett-Davies, S., Pierson, E., Feller, A., Goel, S., & Huq, A. (2017, August). Algorithmic decision making and the cost of fairness. In *Proceedings of the 23rd acm sigkdd international conference on knowledge discovery and data mining* (pp. 797-806).
13. Csizár, I. (1964). Eine informationstheoretische

- ungleichung und ihre anwendung auf  
beweis der ergodizitaet von  
markoffschen ketten. *Magyer Tud.*  
*Akad. Mat. Kutato Int. Koezl.*, 8, 85-  
108.
14. Y. Lalitha Kameswari, "Design and  
Implementation of Controller for  
vocal reduction", "International  
*Journal of Recent Technology and*  
*Engineering (IJRTE)* Vol.8, Issue  
2S8, August 2019.
15. Y. Lalitha Kameswari, "Performance  
Evaluation of Cascaded Multilevel  
Inverter using Neuro Fuzzy  
controller", "*Jour of Adv Research in*  
*Dynamical & Control Systems*,  
Vol.10, 02-Issue, 2018.