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TECHNICAL MAGAZINE

A.Y. 2023 - 2024

DEPARTMENT OF

ELECTRICAL & ELECTRONICS ENGINEERING

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Editor	:	**Dr. G. Rajendar, Head of the Department, EEE Dept.**
Members	:	**Sri. T. Praveen Kumar, Asst. Prof., EEE Dept.** **Dr. G. Sunil Kumar, Asst. Prof., EEE Dept.**

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Message by HoD

With great pleasure and honour I write this foreword. Indeed, this Technical Magazine has a lot to look forward. I am happy that our department started in the year 1994 with B.Tech-EEE programme has completed 25 years during 2019-20. During these 25 years EEE department has crossed several milestones and contributed to society in the form of education to engineering students.

Started with B.Tech – EEE in 1994 with an intake of 60 later enhanced to an intake of 120 in the year 2012. PG programme of M.Tech-Power Electronics was started in the year 2013. B.Tech-EEE program has been accredited by NBA three times under Tier-II from 2011-14 and 2016-19. I am glad to inform that now B.Tech-EEE program has been accredited by NBA under Tier-I for three years from 1st July 2019.

Faculty have contributed whole heartedly for the growth of the Department. The Department has also witnessed the strong force of faculty. At present the Department has faculty strength 31 with diversity of specialization, out of which 15 of them have Doctorates, 05 are pursuing PhD and 11 are with M.Tech. There are four research groups in the department – Power Electronics, Power systems, Electrical Machines & Drives, Control Systems and Instrumentation.

The objective of Technical Magazine is to display the research culture in the department and publications made by the department faculty in terms of Journals / Transactions / Conference Papers during the academic year. Also, it provides an opportunity to students to publish technical articles.

I would like to offer a word of thanks to our readers, our contributors, and our editorial board for their support of the technical magazine and its mission: to improve the quality of research contribution and awareness on recent trends & life-long learning among students. This technical magazine will provide a glimpse of faculty and student contributions made during academic year 2023-2024.

Dr. G. Rajendar
HOD, EEE Dept.

Faculty publications - Journals

List of Journals published by Faculty during A.Y. 2023-24:

S.No.	Name of the Faculty	Title of the Paper	Name of the Journal	Details of Paper
1.	V. Rajagopal & B. Subhash	Optimal Gains for Control Voltage and Frequency in Standalone Wind Energy Conversion System	Journal of The Institution of Engineers (India) SPRINGER	pp. 1303–1319, vol. 104, no. 6, Dec 2023
2.	Dr. B. Jagadish Kumar	Certain Investigations on Modified Fuzzy-based Adaptive Controller for Mitigating the Deviations in Wind System	Grenze International Journal of Engineering and Technology	ISSN:2395-5295, June, 2024
3.	Dr. M. Santhosh	Hybrid attention-based temporal convolutional bidirectional LSTM approach for wind speed interval prediction	Environmental Science and Pollution Research	Vol. 30, pp. 40018–40030, 2023. (https://doi.org/10.1007/s11356-022-24641-x) (SCIE Journal with Impact factor: 5.8)
4.	Dr. M. Santhosh	Outage Forecast-based Preventative Scheduling Model for Distribution System Resilience Enhancement	IEEE Power & Energy Society General Meeting (PESGM)	pp. 1-5, Jul 16-20, 2023

J. Inst. Eng. India Ser. B (December 2023) 104(6):1303–1319
https://doi.org/10.1007/s40031-023-00936-6

ORIGINAL CONTRIBUTION

Optimal Gains for Control Voltage and Frequency in Standalone Wind Energy Conversion System

B. Subhash[1,2] · V. Rajagopal[1,2]

Received: 8 December 2021 / Accepted: 10 October 2023 / Published online: 30 October 2023

Abstract This article discusses about regulation of frequency and voltage of standalone wind conversion system (SWECS) to provide power for linear and nonlinear loads. It consists of induction generator, battery storage system (BSS) connected at DC link of voltage source converter (VSC). When the generated power is more than the consumers load demand, the extra power is diverted to BSS. When consumer load demand exceeds the generated power, the excess power is supplied by a BSS, which regulates the frequency of SWECS. An adaptive theory-improved linear sinusoidal tracer algorithm comprises of two PI controllers to generate active, reactive components of reference source currents, which regulates the terminal voltage. The control algorithm is heart of the system, and PI gains decide how quickly it estimates source currents evaluated for the values of PI controller. The optimization techniques are used to obtain best-suited values and are applied to SWECS to improve the power quality without using phase-locked loop and transformations. The proposed system with control algorithm is executed in three-phase four-wire system by means of various loads for flawlessness in harmonics of source current, voltage at point of common coupling (PCC) as per IEEE-519-1992 standards. The neutral path current compensation is done by star-delta transformer connected between PCC and VSC.

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Keywords Voltage-frequency controller (VFC) · Standalone wind energy conversion system (SWECS) · Star-delta transformer · Induction generator (IG) · PI controller · Battery storage system (BSS) · Dragonfly algorithm (DA) · Particle swam optimization (PSO) · Ant loin optimization (ALO)

Introduction

Voltage and Frequency Controllers

Decentralized electrical power generation systems have been regarded a feasible alternative to the main grid power delivery to remote places due to the considerable realistic cost of transmission and related losses [1]. In light of recent environmental concerns, the use of non-conventional energy sources, which are frequently abundant in such rural areas and include wind, small hydro, tidal, solar, wave, and biomass, has received a lot of attention. Consumer loads can be classified based on their distance from the main grid, such as remote settlements, interior sites, islands, ships, woods, and deserts. Certain loads, such as a standalone wind turbine generating system that offers constant rated voltage and frequency, should require a precise electrification system [2, 3]. Wind energy conversion systems have come to our attention in the last decade due to their environmental benefits and considerable contribution to the production of electrical power in response to increased consumer demand. Power demand varies dramatically between rural, hilly places, and densely populated urban areas. Despite the fact that the world is powered by electricity, there remains a significant disparity between production and consumer demand [4]. We are having a significant problem fulfilling future consumer demand for power due to a lack of fossil fuels, which is

Grenze International Journal of Engineering and Technology, June Issue

Certain Investigations on Modified Fuzzy-based Adaptive Controller for Mitigating the Deviations in Wind System

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Abstract—**In the realm of wind energy systems, the quest for optimal control strategies has led to the exploration of innovative approaches. This study delves into the realm of adaptive control, specifically focusing on a Modified Fuzzy-Based Adaptive Controller designed to mitigate deviations in wind systems. This controller, a product of meticulous investigation, harnesses the power of fuzzy logic with strategic modifications to enhance its adaptability. The proposed controller exhibits a remarkable ability to dynamically adjust its parameters, ensuring optimal performance across diverse operating conditions. Through rigorous experimentation and analysis, the controller's efficacy in mitigating deviations in wind systems has been established, marking a significant advancement in the quest for robust and efficient control strategies. Renewable energy is an ever-changing field, and the Modified Fuzzy-Based Adaptive Controller is a significant advancement. This controller has the ability to adjust parameters dynamically and mitigate deviations in wind systems, which improves the efficiency of wind energy systems and contributes to the broader field of adaptive control. As innovation continues to shape the future of sustainable energy, this controller serves as a testament to the relentless pursuit of a more resilient and environmentally conscious world.**

Index Terms— **WECS, Fuzzy Logic, PMSG, Fuzzy based Adaptive Controller.**

I. INTRODUCTION

In the dynamic arena of renewable energy, pursuing optimal control strategies for wind energy systems has fueled a continuous exploration of inventive methodologies. This research narrative unfolds with a spotlight on adaptive control, honing in on a pioneering solution—the Modified Fuzzy-Based Adaptive Controller. Crafted through a systematic investigative process, this controller emerges as a transformative stride in addressing and rectifying deviations within wind systems. At its conceptual core lies the strategic amalgamation of fuzzy logic, enriched with nuanced modifications that amplify its versatility. This introduction lays the groundwork for an exploration into the intricacies of this controller, spotlighting its prowess in dynamically adapting parameters.
The study showcases the effectiveness of the controller in reducing deviations and optimizing wind energy systems. It advances the field of adaptive control and positions the Modified Fuzzy-Based Adaptive Controller as a key player. This introduction invites readers to a realm where innovation and environmental consciousness come together, guided by the transformative power of this cutting-edge controller.
An effective method to maximize the acquisition of the Maximum Power Point in a direct-driven Permanent

Grenze ID: 01.GIJET.10.2.570

Environmental Science and Pollution Research
https://doi.org/10.1007/s11356-022-24641-x

RESEARCH ARTICLE

Hybrid attention-based temporal convolutional bidirectional LSTM approach for wind speed interval prediction

Bala Saibabu Bommidi[1] · Vishalteja Kosana[1] · Kiran Teeparthi[1] · Santhosh Madasthu[2]

Received: 14 June 2022 / Accepted: 4 December 2022

Abstract

Precise wind speed prediction is crucial for the management of the wind power generation systems. However, the stochastic nature of the wind speed makes optimal interval prediction very complicated. In this paper, a hybrid approach consisting of improved complete ensemble empirical mode decomposition with adaptive noise (ICEEMDAN), temporal convolutional network with attention mechanism (ATCN), and bidirectional long short-term memory network (Bi-LSTM) is proposed for wind speed interval prediction (WSIP). First, ICEEMDAN is used to pre-process the raw data by decomposing the wind signal to several intrinsic mode functions. ATCN is used to reduce the uncertainty from the denoised data and extract the important temporal and spatial characteristics. Then, Bi-LSTM is used to forecast the high-quality intervals for the wind speed. Existing approaches observe a decline in the forecasting performance when the time ahead increases. As a result, the hybrid approach is evaluated using 5-min, 10-min, and 30-min ahead WSIP. To evaluate the novelty of the proposed approach, an experiment is conducted utilising wind speed data from the Garden City, Manhattan wind farm. The experimental results demonstrate that the proposed framework outperformed the comparison models with percentage improvements of 36%, 47%, and 17% for 5-min, 10-min, and 30-min ahead WSIP.

Keywords Temporal convolutional network · Convolutional neural network · Forecasting · Uncertainty · Wind

Introduction

Background

Fossil fuel exhaustion is causing severe climate change due to the fast expansion of many sectors throughout the world.

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Climate change is affecting many people around the world. In Awosusi et al. (2022), the authors looked at how carbon emissions are affected by globalisation of trade, rents on natural resources, economic expansion, and financial sector development. The impact of the climatology parameters on the COVID-19 is explained in Ahmadi et al. (2020). The authors of Habeşoğlu et al. (2022) discussed the oil price's impact on the amount of carbon emission levels in Turkey through financial regulation, energy use, and economic expansion. This gains the attention of the world to clean and endless resources such as solar energy, hydro energy, and wind energy, tidal energy (Council 2020). Especially, wind energy is the most popular renewable energy source with rapid development all over the globe. With 93.6 GW of new global wind installations in 2021, brings the total installed wind capacity to 837 GW. Wind turbine regulations control and wind power system dispatch are based on the dynamic wind speed. According to the cubic relation among wind power and speed, even a little change in wind speed causes a noticeable rise in wind power. Therefore, wind speed is essential for producing wind energy. Wind speed forecasting is challenging, nevertheless, due to the intrinsically nonlinear characteristics of wind

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Outage Forecast-based Preventative Scheduling Model for Distribution System Resilience Enhancement

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Abstract — **Distribution system resilience enhancement is an important topic to ensure customers have access to power supply during extreme events. In fact, certain weather-related extreme events can be predicted ahead of time. Therefore, it is important to investigate how to predict grid outages using extreme weather forecasts, and how outage predictions can be incorporated into distribution system resilience enhancement. In this paper, a preventative scheduling model for distribution systems is proposed. The model targets at allocating resources, especially mobile responsive resources such as mobile backup generators and mobile energy storage systems, to prepare for an extreme event in the day-ahead context. To achieve efficient resource allocation and scheduling, a machine learning-based outage prediction module is developed to predict vulnerable or risky segments of the distribution system based on historical operating records and extreme weather event forecast. By integrating the outage prediction results into the scheduling model, optimal resource allocation can be derived to help distribution systems prepare for an upcoming event and improve resilience performance. A real distribution feeder in North Carolina, U.S. is used in the case study to validate the proposed approach.**

Index Terms—**Distributed energy resources, forecast-based preventative scheduling, machine learning, outage prediction, power system resilience, responsive resource allocation**

I. INTRODUCTION

Power system resilience has been a hot topic in recent years, which addresses the power supply reliability and security against high impact low probability events such as extreme weather events and cyberattacks [1]. As far as distribution systems are concerned, resilience focuses on securing the power supply to end customers during disastrous events to minimize economic and social losses associated with power outages. For typical distribution systems that rely heavily on the upstream transmission system for power supply, little can be done on the distribution end to enhance resilience other than strengthening the grid due to the lack of controllable generation resources.

With the growing integration of distributed energy resources (DERs), distribution systems could still have generation capability from their DERs when there is a major blackout at their upstream transmission system. Hence, reasonable utilization of DER capability becomes a key to improving distribution system resilience [2]. In [3], the authors formulate an islanding strategy in the event of line failures in distribution systems, and they propose a decentralized, multi-agent system to control the DERs. Reference [4] investigates the collaboration of various DERs and legacy devices in distribution system service restoration. Here, mixed-integer, second-order cone programming is used to model the restoration problem. The authors in [5] built a cooptimization method, in where the repair crew and mobile power source were jointly dispatched for electric service restoration. In [6], the authors focus on comparing the load restoration performances using fixed and variable time steps. Here, the restoration model for the distribution system is a mixed-integer, linear programming (MILP) problem. Reference [7] develops a new set of quantitative metrics with clear physical interpretation to comprehensively evaluate power system resilience and integrate them into power system optimization models for resilience enhancement. Behind-the-meter DERs were controlled to improve distribution system resilience in [8]. The restoration of secondary distribution network with distributed generators was studied in [9].

Overall, existing works have explored the feasibility of implementing DERs to assist distribution system service recovery and resilience enhancement. However, their focuses are either on long-term planning (e.g., grid strengthening) or real-time DER control. For certain extreme events such as hurricane and flood, it is possible to get a pretty good prediction of the event propagation hours or days ahead. If this event prediction information can be leveraged by utility operators, it is possible for them to adjust their operating schedules and allocate emergency responsive resources such as backup generators to the most vulnerable grid segments to improve resilience. To achieve this, the following two questions need to be addressed:

- For extreme events that can be predicted, how to efficiently map the extreme event prediction to grid outage prediction, and how to improve the outage prediction accuracy.
- With a credible outage prediction result, what measures can be taken to allocate responses and controllable assets to prepare for the outage event.

To this end, the major contents and contributions of this paper includes:

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Faculty publications – Conference Papers

List of Conference Papers published by Faculty during A.Y. 2023-24:

S.No.	Name of the Faculty	Title of the Paper	Name of the Conference	Details of Paper
1.	Prof. C. Venkatesh	5-phase Multilevel Inverter for EV Application	IEEE 20th India Council International Conference (INDICON), Hyderabad, India	pp. 25-30, 2023, DOI: 10.1109/INDICON59947.2023.10440847
2.	Prof. C. Venkatesh	Five Phase Split-Source Inverter with Shifted Pulse Width Modulation	International Conference on Emerging Advances and Applications in Green Energy (ICEAAGE-2024), Prasad V. Potluri Siddhartha Institute of Technology, Kanuru, Vijayawada, Andhra Pradesh, India.	29th February 2024
3.	Prof. V. Rajagopal	Truly-NTD-PLL Control Algorithm for DVR	IEEE 4th International Conference on Sustainable Energy and Future Electric Transportation (SEFET-2024), Hyderabad, India	pp. 1-9, 31 July-03 August 2024.
4.	Prof. V. Rajagopal	Control of DVR Using Multilayer Gamma Filter Under Non-Ideal Grid Conditions	IEEE 3rd International Conference on Sustainable Energy and Future Electric Transportation (SEFET-2023), Bhubaneswar, India	pp. 1-9, 9-12 August 2023.
5.	Dr. M. Santhosh	Ensemble Deep Learning Model for Power System Outage Prediction for Resilience Enhancement	North American Power Symposium (NAPS) - IEEE	pp. 1-6, 2023 October 15. (https://doi.org/10.1109/NAPS58826.2023.10318685)
6.	Dr. M. Santhosh	Outage Data Analytics for Correlating Resilience and Reliability	North American Power Symposium (NAPS) - IEEE	pp. 1-6, 2023 October 15. (https://doi.org/10.1109/NAPS58826.2023.10318656).

5-phase Multilevel inverter for EV application

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Abstract— **The aim of this paper is to reduce the THD in a 5-phase multilevel neutral point clamped inverter and to improve the performance of the 5-phase induction motor used in EV applications. Voltage control of this 5-phase multilevel inverter is done using three different multicarrier PWM techniques (PD, POD, APOD). Simulation analysis is performed using Simulink with R, RL loads connected to the multilevel inverter and obtain load voltage, current waveforms, and THD analysis. This paper implements a better technique for electric vehicle control using a 5-phase induction motor drive with a multilevel inverter system and performance analysis of speed, torque, and stator currents using Matlab-simulink software. The results show that the PD modulation technique provides the lowest THD performance for the system and the motor attains a fast steady state.**

Keywords— Multi-carrier pulse width modulation, multiphase multilevel inverter, neutral point clamped inverter, multiphase induction motor, total harmonic distortion

I. Introduction

Multilevel inverters have gained widespread popularity in the power industry due to their ability to control high voltage and power drives with improved efficiency and reduced electromagnetic interference [1]. Neutral point clamped (NPC) inverters are commonly used in industrial applications, and multi-carrier pulse width modulation (PWM) techniques can further enhance the performance of NPC inverters[2]. The use of multi-carrier pulse widths modulation techniques, such as phase disposition (PD), phase opposition and disposition (POD), and alternative phase-opposition disposition (APOD), can improve the power quality and reject common mode voltage, as well as address the issue of DC-link capacitor balancing in multilevel inverters. However, these techniques can also result in higher Total Harmonic Distortion (THD) compared to the PD PWM method [3]. Enhancing the THD performance of a 5-Phase, 3-Level Neutral Point Clamped (NPC) inverter is proposed in [4]. The goal is to achieve lower THD levels in the output waveform of the inverter, which can lead to improved efficiency, reduced losses, and higher-quality power output [5]-[6].

Multiphase inverters have gained popularity in high-power applications due to their advantages over single-phase inverters. These advantages include improved reliability, better output waveform quality, and reduced harmonic distortion. They have a wide range of applications, including high-power applications, uninterruptible power supply (UPS) systems, high-voltage DC transmission, variable frequency drives, pumps, and conveyors[7]. One of the most significant applications of multiphase inverters is in electric vehicles (EVs) where the demand for high-power and reliable electrical drives is increasing. In EVs, induction motors are often used as the main drive and precise speed control is essential for optimal performance. This is achieved through the use of advanced control techniques such as Field Oriented Control (FOC) and Direct Torque Control (DTC)[8]. Additionally, five-phase motor drives are particularly suitable for applications where high-power density, high speed, and high reliability are required, such as aerospace, automotive, and renewable energy systems[9].

Multiphase motors are widely used due to their several advantages when compared to traditional three-phase motors such as higher power density, improved fault tolerance, increased efficiency, and provide greater flexibility in terms of control which gives smoother operation. Five-phase three-level induction motor is a type of multiphase motor consisting of five stator windings and three levels of voltage making them ideal for critical applications that require high reliability. During the next 20 years, multiphase motor drives have attracted and has specific applications namely, Electric ship propulsion, traction (including electric and hybrid electric vehicles and aircraft[10]. Multi-phase motors have advantages of improved torque-speed characteristic, reduced current per phase without increasing the voltage per phase and reduced Harmonic current. Multiphase induction motor with increased number of phases used in many applications because of their safety and reliability[11].

This paper will focus on utilizing three different multi-carrier PWM techniques, PD, POD, and APOD, and perform a simulation analysis using simulink with R & RL loads to obtain the load voltage and current waveforms and THD analysis. A 5-phase induction motor will also be modelled to demonstrate for EV application. The results of this research will provide insights into the THD performance of different multi-carrier PWM techniques in NPC inverters and inform the selection of the most effective PWM method for high-power applications.

II. Multiphase-Multilevel Inverter

The topology of the three-level five-phase inverter is shown in Fig.1. It consists of five legs and each leg has four switches which must be controlled in two complementary combination pairs only.

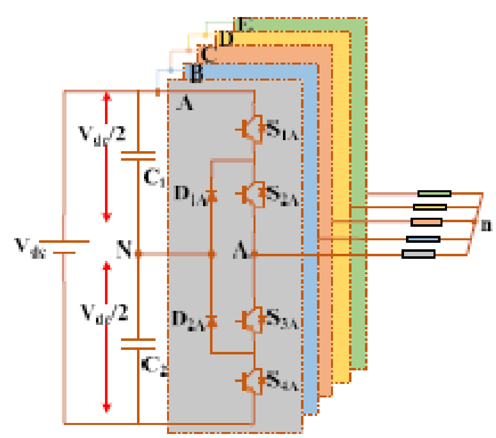

Fig. 1. 3L NPC inverter for a 5-phase load.

Five Phase Split-Source Inverter with Shifted Pulse Width Modulation

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ABSTRACT

Electric vehicles are finding wide increasing application in recent years. The development of inverters and regeneration technology are adding to the increased used of electric vehicles. In this paper, shifting sinusoidal pulse width modulation (PWM) and its impact on inverter output waveform quality is explored. Our goal was to determine whether shifting the modulation to the positive half cycle could reduce distortion and result in a more pristine output waveform. To ascertain the effectiveness of this tactic, we conducted simulation analysis with various control strategies and examined the results. Utilising the shifted sinusoidal PWM technique, we discovered that Total Harmonic Distortion (THD) was significantly reduced in the inverter output voltage. Investigations were also conducted into the impact of various duty cycles and modulation frequencies on waveform quality. Shifted sinusoidal PWM technique is a workable and affordable solution because it integrates well with existing systems. It is simple to use in many different applications, such as audio systems, motor control, and power electronics. This strategy is very helpful in many different sectors since it may produce precise control and high-quality output. To improve the efficiency of the system multiphase inverter is considered. To sum up, multiphase inverter with shifted sinusoidal PWM has given better results. Simulation results of multiphase inverter operation with RL load is demonstrated.

Keyword: *- Multiphase inverter, Split source inverter, Sinusoidal PWM, Current source inverter*

1 INTRODUCTION

Power electronics is the effective use of power semiconductor devices for the conversion and management of electric power. Modern technology is the foundation of power electronics, which have many applications. Power electronics converters are crucial components in the process of converting signals with electric power to other signals, An inverter is a power electrical device that converts DC (direct current) signal to a AC (alternate current) signal. Electric cars, continuous power distribution, and battery-operated mobile phones are just a few of the many uses for inverters.

Inverters can be classified as grid-connected or stand-alone[1]. Voltage source inverters (VSI), current voltage inverters (CSI), Z-Source inverters, and quasi-Z- Source inverters are among the several single- and three-phase inverters that are available. Expanding the five phase inverters to address the drawbacks of single and three phase inverters led to the development of multiphase inverters as a result of contemporary technology and methodology. A five-phase inverter can offer enhanced efficiency, reduced copper losses, increased output power, and control over the flow of both actual and reactive power in place of a three-phase inverter [2] .

The split source inverter (SSI) was developed recently to address every drawback of the CSI, VSI, and ZSI. Originally designed for single- and three-phase topologies that require continuous input current flow, DC voltage, lower passive components, and less voltage stresses between switches for high-voltage gains[3]. The SSI topology reduces the volume and weight of the inverters, as well as the number of switches, due to the passive sections or components The SSI may achieve lower ripple current and improved efficiency when compared to conventional inverters[4].

2 TYPES OF MULTIPHASE INVERTERS

As the technology and methodology increasing in the inverter topology and integrated with based on their function and working. The multiphase inverters are classified with based on their different construction and working principle. The multiphase inverters are discussed below.

2.1 Current Source Inverter

The current source inverter, sometimes referred to as the current feed inverter, generates a three-phase or single-phase output after converting the input DC to AC. Ten-switches are used by the five-phase current source inverter (CSI) to reduce harmonic distortion and improve the output waveform[5]. CSI can be used in electric vehicle (EV) chargers, induction heating, variable frequency drives, and renewable energy systems like solar photovoltaic (PV) systems, power systems employ power factor correction[6]. Figure 1 shows the cirruit connection of 5-phase

Truly-NTD-PLL Control Algorithm for DVR

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***Abstract*— The paper discusses how to use a DVR to resolve voltage related topics for instance harmonics, sags, surges, and unbalance in supply voltages. The DVR is designed to address these concerns and offer a consistent power supply for sensitive loads. A strategy based on a really truly-non-frequency-dependent-transport-delay PLL (tNTD-PLL) is applied in evaluation of frequency, fundamental component and phase angle, which are then employed in a compensator to improve power quality by decreasing these values. The tNTD-PLL adds a delay element to the PLL's feedback loop, increasing transfer latency while decreasing double frequency oscillatory and offset errors. er than the targeted frequency. The control algorithm generates reference voltages, which are subsequently compared to the load voltages (sensed). The fault is subsequently fed into the PWM converter, which produces pulses for the DVR. It injects the voltages required to enhance the voltage-based issues related to power quality. The projected DVR is simulated and designed by means of Simulink/MATLAB. A laboratory model of DVR with d-SPACE MicroLab-Box validates the simulation results.**

Index Terms*— *Truly non-frequency-dependent transfer delay PLL, Dynamic voltage restorer (DVR), Sag, Swell, Harmonics, unbalance, Optimization method.

I. Introduction

Widespread usage of electronics in supply network causes various type of power quality issues [1]. Bollen and Gu [2] explores the causes and consequences of these power quality concerns, offering information about how they harm sensitive electronic equipment's. Singh *et. al.* [3] cover a wide range of challenges, including harmonics, voltage sags, and flicker, and provide practical methods for improving power quality. Zhan *et. al.* [5] provide a three-dimensional voltage SV-PWM algorithm-based DVR. The authors provide a novel strategy to addressing power quality challenges, notably imbalanced and distorted loads [4]. Ghosh *et. al.* [5] designed a capacitor-supported DVR for distorted and unbalanced loads. Jurado *et. al.* [6] studied the neural network control in DVRs to improved control methods, which primes to the growth of adaptive power quality results. Nielsen et al. investigate the various methods, giving helpful information for researchers and engineers working in DVR design and implementation [7]. Vilathgamuwa *et. al.* [8] study the IDVR's technical specifications and ability to reduce voltage sags, providing valuable insights. Ho *et. al.* [9] examined voltage concerns and offered a control technique to increase DVR dynamic response. Lam et al. [10] studied and developed an effective strategy to decrease voltage fluctuations. Saleh *et. al.* [11] are interested in using wavelet transforms to detect and control voltage changes in real time. Roncero-Sanchez and Acha introduced a control mechanism for enhance DVR voltage rebuilding abilities. This study enhances multilevel converter-based DVRs and their use for enhancing power quality [12]. Babaei *et. al.* [13] studied the use of direct converters to improve DVR performance in decreasing voltage fluctuations, and their findings shed light on the applications of this novel technology for improved power quality. Ajaei *et. al.* [14] provided an effective and quick and control system for dynamic voltage restorers, with an emphasis on the creation of a control strategy that employs optimization approaches to improve DVR dynamic responsiveness and assure speedy and efficient compensation of voltage disturbances. The IEEE 519-2014 Recommended Practices are a fundamental document that establishes the principles and standards for harmonic control in electric systems [15]. Jayaprakash et al. [16] investigate the control of a low-power DVR using a battery energy storage device. Chen *et al.* [17] present a novel approach for identifying synchronous phase-locked loops (SPLLs). Rauf and Khadkikar [18] investigate the integration of solar systems with dynamic voltage restorers. Carlos *et. al.* [19] applies two dc-links and series converters to investigate dynamic voltage restorers for three phase systems. Mirjalili [20] analyzed the algorithm's application in optimization issues, demonstrating its efficiency in identifying solutions. Biricik and Komurcugil [21] offer a sliding mode control approach designed for single-phase DVRs. Danbumrungtrakul et al. apply the zero active power tracking technique to assess the capability enhancement of dynamic voltage restorers [22]. Golestan *et. al.* evaluates Kalman filter-based PLLs in steady-state and discuss their utility in power systems [23]. Li *et. al.* offers a new voltage compensation philosophy for dynamic voltage restorers based on three-phase voltage elliptical parameters [24]. Pradhan and Mishra propose a p-q theory based DVR to improve PQ. [25]. Naidu *et. al.* [26] describe a DVR using a quasi-newton strategy based on and optimized PI gains. Assiri *et. al.* [27] have discussed development of various meta-heuristic algorithms and their classification and applications. Some of the algorithms are ant lion optimization, bat algorithm soccer game optimization etc. Tu *et. al.* [28] perform a thorough analysis on using a DVR to nullify voltage PQ issues, providing useful insights into DVRs increased capability for a broader spectrum of disturbances. Kandil and Ahmed look into the control and operation of a DVR with a self-supported dc bus [29]. Khergade *et. al.* [30] investigate the impact of sag on power semiconductor drives and propose a mitigating strategy using an ESRF theory-based DVR. Akhtar and Saha [31] describe an NTD PLL with a simple technique for double-frequency oscillation rejection, as well as a unique PLL design for dynamic voltage restorers that improves performance by rejecting double-frequency oscillations. Biricik *et. al.* [32] present a control method for DVRs based on a frequency-adaptive Brockett oscillator.

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Control of DVR Using Multilayer Gamma Filter under Non-ideal Grid Conditions

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***Abstract*—This paper investigates dynamic voltage restorers (DVRs) as a solution to voltage-based power quality issues. A control algorithm based on a Multilayer Gamma Filter is proposed to compensate for voltage sag, voltage swell, distortions, and phase voltage discrepancies caused by various factors in series-connected devices. To improve power quality, the proposed Multilayer Gamma Filter-based control algorithm is used for the compensator. In several ways, the Multilayer Gamma Filter outperforms traditional filter designs. To begin with, it is adaptive, which means it can change its parameters in response to various types of disturbances. Second, it has a lower computational complexity than other filters, making it a more efficient option for real-time applications. Finally, it has a high accuracy in estimating input signal parameters and a fast transient response. The system performs satisfactorily even under less-than-ideal conditions with wide voltage and load variations. The control algorithm employs two proportional integral (PI) gains to maintain the dc link voltage and terminal voltage stable. The gains of the PI controllers are critical for estimating reference load voltages correctly. The salp swarm optimization algorithm is used to optimize DVR gains. The salp swarm optimization algorithm has been demonstrated to be effective in PI tuning, providing faster convergence and improved performance over traditional tuning methods. The control system can achieve better regulation of the process variable and overall system performance by optimizing the PI gains. The optimized gains are applied to a fourth-order multilayer gamma filter to extract reference load voltages. To extract reference load voltages, the optimized gains are applied to a fourth-order multilayer gamma filter.**

***Keywords*— Dynamic voltage restorer, Optimization Algorithm, multi-layer gamma filter, voltage unbalance, voltage swells, voltage sags, voltage distortions.**

I. Introduction

The Dynamic Voltage Restorer (DVR) is a custom power device that is used to reduce voltage sag and swell in power systems. It is a sophisticated power electronics device that acts as a voltage source for the load during voltage sag and swell events [1]. Singh et al. provide a thorough examination of power quality issues and mitigation techniques. The book discusses the causes and effects of various power quality issues, such as voltage sags and interruptions, and offers various mitigation techniques for these issues. The book is useful for both academics and power industry practitioners [2]. Vedam and Sarma's research focuses on VAR compensation in power systems. The book discusses various VAR compensation techniques, such as reactive power compensation, static VAR compensators, and dynamic VAR compensators. The book is an excellent resource for power quality researchers and practitioners [3]. Akagi et al. present a quad-series voltage source PWM converter-based active power filter.

The paper presents simulation and experimental results to demonstrate the effectiveness of the proposed filter, as well as a detailed analysis of its operation and performance. The paper is useful for researchers working on active power filter development [4]. Principe et al. introduce the Gamma-Filter, a new class of adaptive IIR filters. The paper presents simulation results as well as a detailed analysis of the filter's structure and operation to demonstrate its effectiveness in filtering power quality disturbances. Researchers working on the development of adaptive filters for power quality applications will find the paper useful [5]. Weissbach et al. propose using flywheel energy storage to compensate for dynamic voltage on distribution feeders. The authors look into the effectiveness of a flywheel-based energy storage system in mitigating voltage fluctuations on a distribution feeder. According to the experimental results, the flywheel energy storage system is an effective solution for voltage compensation on distribution feeders [6]. In this paper, Woodley et al. discuss their experience with an inverter-based dynamic voltage restorer (DVR). The authors describe the design and implementation of a digital video recorder (DVR) for voltage regulation on a 415 V three-phase distribution system. The experimental results demonstrate that the DVR is a viable solution for reducing voltage sags and swells [7]. Using particle swarm optimization, Liu and Hsu propose a self-tuning PI controller for a static synchronous compensator (STATCOM) (PSO). The authors investigate the proposed controller's performance in regulating the voltage of a power system. The simulation results demonstrate that the proposed controller is capable of keeping the voltage within the specified limits [8]. In this paper, Shukla and Singh propose using a multilayer gamma filter-based control for a distribution static synchronous compensator (DSTATCOM). The authors investigate the proposed controller's performance in improving the power quality of a non-ideal distribution system. According to the simulation results, the proposed controller is effective at mitigating voltage sags and swells [9]. In this paper, Woodley and Ewing present their field experience with dynamic voltage restorer (DVR) systems. The authors describe how to install and operate DVRs on various distribution systems. The DVR is an effective solution for mitigating voltage sags and swells, according to field results [10]. Choi et al. proposed a dynamic voltage restorer (DVR) that injects the least amount of energy into the system in order to restore voltage sag. To control the voltage restoration process, the proposed DVR employs the minimum energy injection algorithm. The authors demonstrated that the proposed method restores voltage and reduces total energy required [11]. Zhan et al. proposed a voltage space vector PWM-controlled dynamic voltage restorer. The proposed DVR is intended to reduce distribution system voltage sags and swells. The authors demonstrated that the proposed DVR can regulate voltage and has a fast response time [12]. Fitzer et al. proposed a technique for reducing saturation in dynamic voltage restorer connection transformers. The authors

Ensemble Deep Learning Model for Power System Outage Prediction for Resilience Enhancement

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***Abstract*— Extreme weather events can cause power outages anywhere, but quite extensively along the U.S. southeastern coastline. Accurate outage prediction before a hurricane landfall is essential for reducing the impacts from distribution outage management and restoration planning perspectives. An outage prediction model (OPM) is developed to predict outages associated with substations based on data collated from multiple sources using tree-based ensemble machine learning regression algorithm. For this study, publicly available data as well as actual outage data from a major utility in the U.S. are employed. Performance validation of outage prediction models is done using several extreme weather events data over the past decade. Results confirm enhancement in accuracy for power outage predictions over baseline approaches.**

Keywords*— *Artificial neural network, critical infrastructure, data analytics, decision tree, ensemble boosted tree, extreme weather event, machine learning, outage prediction model

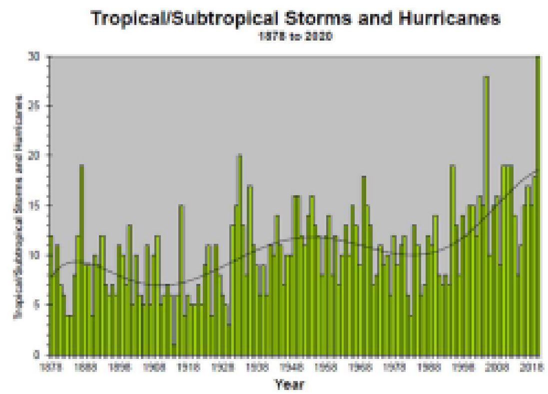

Fig. 1. Number of combined tropical storms, subtropical storms, and hurricanes each year from 1878 to 2020. [2]

I. Introduction

Extreme weather events (EWE), like hurricanes, are the main cause of large-scale power outages along the U.S. coastlines. As shown in Fig. 1, EWEs have been increasing over the last two decades indicating a connection to climate change. As a result, the number of power outages appears to be increasing in the time between 2010 to the present. The average duration of interruptions customers experienced annually from 2013 to 2029 was consistently around four hours. On average, U.S. electricity customers experienced just over eight hours of electric power interruptions in 2020 [1].

The occurrence of power outages is decided by a complicated inter-relationship among vegetation cover, infrastructure, and atmospheric phenomena. Now-a-days, data-driven approaches have captured global attention for predicting loads, solar irradiance, wind speeds and even the number of power outages in distribution system [3]. Accurate prediction of power outages before the arrival of an EWE assists utilities with superior resource planning, and improving the rate of restoration, which in turn, enhances power system resilience.

The first OPM was developed using negative binomial regression for evaluating the relationship between wind speed and transformers using three hurricanes' data [4]. Then generalized linear models (GLMs) were implemented for outage prediction to inspect the significance of hurricane and ice storm variables [5]. In [6], the authors developed generalized additive models (GAMs) that can capture non-linearity in the data. Since then, non-parametric models like classification and regression trees (CART), and Bayesian additive regression trees (BART) were utilized as OPMs [7]. These non-parametric models outperform parametric models such as GLMs and GAMs. Researchers have utilized data-driven approaches to predict the threats to power systems under EWE [8], [9]. The authors implemented cumulative time failure OPM utilizing the rainfall data of hurricane, maximum wind speed, and wind speed duration [10]. In [11], the authors implemented an approach for distribution networks to predict the risk level of power outage considering weather factors but without considering factors such as the region of study. To enhance the OPM accuracy, the prediction area was first meshed into grid cells in [12]. In addition, a multistage grid division framework is developed for distribution network planning in [13]. Boosted trees are employed for spatial distribution of power outages in a 2 Km grid using the weather and land cover data [14]. Existing outage prediction methods that take a granular approach focus on predicting the number of customers affected or the number of outages within a specific geographical grid cell over the entire duration of an EWE. While such perspectives are essential, they may not provide vital spatial and temporal information required to form microgrids for resiliency improvements. There is a need for granular substation-level predictions with a focus on the number of customers affected and the number of outages at the substation level. In this research work, power outages are predicted using ensemble model based on a boosting algorithm. Results show that ensemble model gives the highest accuracy compared to baseline models. The main contributions of this research work are:

- Outage predictions by actual substation-level with definite time horizons instead of generic grid cells.
- The development of machine learning (ML) models implemented for power outage prediction problem, which emphasizes outage predictions for EWE.
- Granular substation-level predictions with focus on the number of customers affected and the number of

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Outage Data Analytics for Correlating Resilience and Reliability

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***Abstract*—In the last few decades, extreme weather events (EWEs) have become more frequent, especially in the south-eastern part of the U.S. These EWEs affect the distribution grid greatly, resulting in long-duration power outages. To fully understand the outcomes of these catastrophic events and to correlate the impact on the reliability and resiliency of the utility company, multiple years of historical EWE-related outage data collected from a utility company are analyzed. Moreover, this study utilizes the System Average Interruption Duration Index (SAIDI) matrix to analyze the EWEs. This study finds overgrown vegetation as one of the main reasons for outages during EWEs. Besides, loss of transmission and generation also contribute significantly to outage events resulting in a high percentage of customers being affected for long periods.**

***Index Terms*—Extreme weather event, distribution network, outage data, statistical analysis.**

I. INTRODUCTION

Extreme weather events (EWEs) have been on an upward trend over the last two decades, most likely because of climate change. These EWEs might have a significant impact on the power grid. An EWE is defined as an event when the weather variable values increase or decrease from a threshold value that is near the upper or lower part of the range of observed variable values [1]. EWEs such as hurricanes and storms are some of the main reasons for large-scale power outages in the distribution system. Due to these events, the number of power outages rose dramatically from 2010 to 2021. In the United States alone, in between 2003 to 2012, more than 10 million customers were affected due to EWEs [2]. Statistical analyses of distribution network outages caused by EWEs is essential for distribution outage management and restoration planning. During the EWE, the occurrence of power outages is decided by a complicated reaction among atmospheric phenomena, infrastructure, and vegetation cover [3]. The economic impact of inflation-adjusted cost of weather-related power outages is estimated to be $25 to $70 billion annually in the U.S. [4]. 2005's Hurricane Katrina and 2017's Hurricane Harvey inflicted $125 billion each in damages, and are considered to be the costliest tropical cyclones on record affecting over 15 million customers [5]. Resiliency studies emphasize the impact of low-probability, high-impact events such as hurricanes. One needs to develop a road map for use in the integrated resource planning process to support investments that build grid resiliency while maintaining affordable and reliable power. Reliability is commonly a component of utility planning and operation, yet resilience is an emerging emphasis in the aftermath of large weather-related events [6]. Grid reliability studies focus on expected disruption events as well as to evaluate the mean time between failures and system availability through well-known metrics such as SAIFI (System Average Interruption Frequency Index) and SAIDI (System Average Interruption Duration Index).

Various data analysis-based studies have been done on EWE-related outages. In [7], 5 years of utility outage data have been utilized to perform statistical analysis of resilience events. Moreover, this study extracted and computed standard resilience metrics. The authors in [8] used historical outage data from major electric power companies on the east coast and developed accelerated failure time models to estimate ice-storm and hurricane-related outage duration. There is a need to conduct case studies in the context of affected areas, emphasizing resiliency to prepare the areas for EWEs. In [9], outage data has been analyzed for transformer-related outages. Although this work specifically focuses on transformer-related outages, common foul weather conditions have also been included in the study.

The coastal regions of North Carolina are experiencing EWEs on a regular basis. A total of 36 tropical storms, along with three extreme tropical storm-driven flood events, happened from 1999 to 2018 [10]. These EWEs result in catastrophic human impacts as well as damage to the grid infrastructure, making the situation even worse. Outage data analysis is necessary for this region at the distribution system level for overall system reliability and for planning an affordable, resilient, and sustainable grid. In this paper, 10 years' worth of outage data in the service region of one utility company in the southeastern part of North Carolina is analyzed. EWEs will gradually become more frequent due to global warming, and the severity of this type of resilient event will increase [11]. A major contribution of this paper is to analyze the impact of EWEs on the electric power distribution system. Hurricane Florence, which made landfall in 2018, is an example of an EWE that caused widespread damage to the power infrastructure leading to long-duration outages in the Carolinas. In addition, the reliability indices from major event days (MED) are studied and compared to non-major event days. The main goal of this outage study is

Student's Publications

List of Students' Journals and Conference Papers published during A.Y. 2023-24:

S.No.	Name of the Student(s)	Title of the Paper	Name of the Journal/Conference	Details of Paper
1	J. Sirichandana, K. H. Kumar, V. Sravan Kumar and S. Aravind	5-phase Multilevel Inverter for EV Application	IEEE 20th India Council International Conference (INDICON), Hyderabad, India	pp. 25-30, 2023, DOI: 10.1109/INDICON59947.2023.10440847
2	Spandana Priya Banka, Navya Nivedhitha Hanamkonda, Nagaraju Duddu, Varunraj Gaddam	Five Phase Split-Source Inverter with Shifted Pulse Width Modulation	International Conference on Emerging Advances and Applications in Green Energy (ICEAAGE-2024), Prasad V. Potluri Siddhartha Institute of Technology, Kanuru, Vijayawada, Andhra Pradesh, India.	29th February 2024
3	P. Sai Vaibhav Likith Chandra, D. Nipun Nishnath, M. Preetham and K. Sai Vishwas	Certain Investigations on Modified Fuzzy-based Adaptive Controller for Mitigating the Deviations in Wind System	Grenze International Journal of Engineering and Technology	ISSN:2395-5295, June, 2024

5-phase Multilevel inverter for EV application

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Abstract— **The aim of this paper is to reduce the THD in a 5-phase multilevel neutral point clamped inverter and to improve the performance of the 5-phase induction motor used in EV applications. Voltage control of this 5-phase multilevel inverter is done using three different multicarrier PWM techniques (PD, POD, APOD). Simulation analysis is performed using Simulink with R, RL loads connected to the multilevel inverter and obtain load voltage, current waveforms, and THD analysis. This paper implements a better technique for electric vehicle control using a 5-phase induction motor drive with a multilevel inverter system and performance analysis of speed, torque, and stator currents using Matlab-simulink software. The results show that the PD modulation technique provides the lowest THD performance for the system and the motor attains a fast steady state.**

Keywords— Multi-carrier pulse width modulation, multiphase multilevel inverter, neutral point clamped inverter, multiphase induction motor, total harmonic distortion

I. Introduction

Multilevel inverters have gained widespread popularity in the power industry due to their ability to control high voltage and power drives with improved efficiency and reduced electromagnetic interference [1]. Neutral point clamped (NPC) inverters are commonly used in industrial applications, and multi-carrier pulse width modulation (PWM) techniques can further enhance the performance of NPC inverters[2]. The use of multi-carrier pulse widths modulation techniques, such as phase disposition (PD), phase opposition and disposition (POD), and alternative phase-opposition disposition (APOD), can improve the power quality and reject common mode voltage, as well as address the issue of DC-link capacitor balancing in multilevel inverters. However, these techniques can also result in higher Total Harmonic Distortion (THD) compared to the PD PWM method [3]. Enhancing the THD performance of a 5-Phase, 3-Level Neutral Point Clamped (NPC) inverter is proposed in [4]. The goal is to achieve lower THD levels in the output waveform of the inverter, which can lead to improved efficiency, reduced losses, and higher-quality power output [5]-[6].

Multiphase inverters have gained popularity in high-power applications due to their advantages over single-phase inverters. These advantages include improved reliability, better output waveform quality, and reduced harmonic distortion. They have a wide range of applications, including high-power applications, uninterruptible power supply (UPS) systems, high-voltage DC transmission, variable frequency drives, pumps, and conveyors[7]. One of the most significant applications of multiphase inverters is in electric vehicles (EVs) where the demand for high-power and reliable electrical drives is increasing. In EVs, induction motors are often used as the main drive and precise speed control is essential for optimal performance. This is achieved through the use of advanced control techniques such as Field Oriented Control (FOC) and Direct Torque Control (DTC)[8]. Additionally, five-phase motor drives are particularly suitable for applications where high-power density, high speed, and high reliability are required, such as aerospace, automotive, and renewable energy systems[9].

Multiphase motors are widely used due to their several advantages when compared to traditional three-phase motors such as higher power density, improved fault tolerance, increased efficiency, and provide greater flexibility in terms of control which gives smoother operation. Five-phase three-level induction motor is a type of multiphase motor consisting of five stator windings and three levels of voltage making them ideal for critical applications that require high reliability. During the next 20 years, multiphase motor drives have attracted and has specific applications namely, Electric ship propulsion, traction (including electric and hybrid electric vehicles and aircraft[10]. Multi-phase motors have advantages of improved torque-speed characteristic, reduced current per phase without increasing the voltage per phase and reduced Harmonic current. Multiphase induction motor with increased number of phases used in many applications because of their safety and reliability[11].

This paper will focus on utilizing three different multi-carrier PWM techniques, PD, POD, and APOD, and perform a simulation analysis using simulink with R & RL loads to obtain the load voltage and current waveforms and THD analysis. A 5-phase induction motor will also be modelled to demonstrate for EV application. The results of this research will provide insights into the THD performance of different multi-carrier PWM techniques in NPC inverters and inform the selection of the most effective PWM method for high-power applications.

II. Multiphase-Multilevel Inverter

The topology of the three-level five-phase inverter is shown in Fig.1. It consists of five legs and each leg has four switches which must be controlled in two complementary combination pairs only.

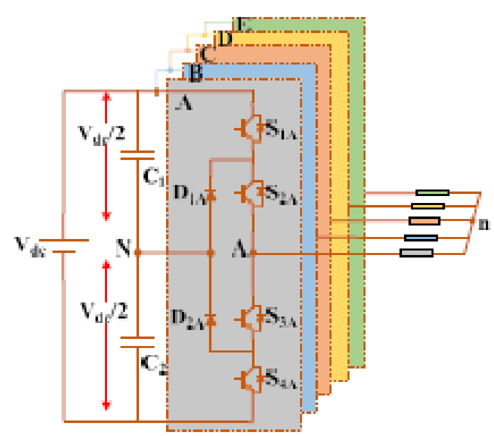

Fig. 1. 3L NPC inverter for a 5-phase load.

Five Phase Split-Source Inverter with Shifted Pulse Width Modulation

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ABSTRACT

Electric vehicles are finding wide increasing application in recent years. The development of inverters and regeneration technology are adding to the increased used of electric vehicles. In this paper, shifting sinusoidal pulse width modulation (PWM) and its impact on inverter output waveform quality is explored. Our goal was to determine whether shifting the modulation to the positive half cycle could reduce distortion and result in a more pristine output waveform. To ascertain the effectiveness of this tactic, we conducted simulation analysis with various control strategies and examined the results. Utilising the shifted sinusoidal PWM technique, we discovered that Total Harmonic Distortion (THD) was significantly reduced in the inverter output voltage. Investigations were also conducted into the impact of various duty cycles and modulation frequencies on waveform quality. Shifted sinusoidal PWM technique is a workable and affordable solution because it integrates well with existing systems. It is simple to use in many different applications, such as audio systems, motor control, and power electronics. This strategy is very helpful in many different sectors since it may produce precise control and high-quality output. To improve the efficiency of the system multiphase inverter is considered. To sum up, multiphase inverter with shifted sinusoidal PWM has given better results. Simulation results of multiphase inverter operation with RL load is demonstrated.

Keyword: *- Multiphase inverter, Split source inverter, Sinusoidal PWM, Current source inverter*

1 INTRODUCTION

Power electronics is the effective use of power semiconductor devices for the conversion and management of electric power. Modern technology is the foundation of power electronics, which have many applications. Power electronics converters are crucial components in the process of converting signals with electric power to other signals. An inverter is a power electrical device that converts DC (direct current) signal to a AC (alternate current) signal. Electric cars, continuous power distribution, and battery-operated mobile phones are just a few of the many uses for inverters.

Inverters can be classified as grid-connected or stand-alone[1]. Voltage source inverters (VSI), current voltage inverters (CSI), Z-Source inverters, and quasi-Z- Source inverters are among the several single- and three-phase inverters that are available. Expanding the five phase inverters to address the drawbacks of single and three phase inverters led to the development of multiphase inverters as a result of contemporary technology and methodology. A five-phase inverter can offer enhanced efficiency, reduced copper losses, increased output power, and control over the flow of both actual and reactive power in place of a three-phase inverter [2] .

The split source inverter (SSI) was developed recently to address every drawback of the CSI, VSI, and ZSI. Originally designed for single- and three-phase topologies that require continuous input current flow, DC voltage, lower passive components, and less voltage stresses between switches for high-voltage gains[3]. The SSI topology reduces the volume and weight of the inverters, as well as the number of switches, due to the passive sections or components The SSI may achieve lower ripple current and improved efficiency when compared to conventional inverters[4].

2 TYPES OF MULTIPHASE INVERTERS

As the technology and methodology increasing in the inverter topology and integrated with based on their function and working. The multiphase inverters are classified with based on their different construction and working principle. The multiphase inverters are discussed below.

2.1 Current Source Inverter

The current source inverter, sometimes referred to as the current feed inverter, generates a three-phase or single-phase output after converting the input DC to AC. Ten-switches are used by the five-phase current source inverter (CSI) to reduce harmonic distortion and improve the output waveform[5]. CSI can be used in electric vehicle (EV) chargers, induction heating, variable frequency drives, and renewable energy systems like solar photovoltaic (PV) systems, power systems employ power factor correction[6]. Figure 1 shows the cirruit connection of 5-phase

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Certain Investigations on Modified Fuzzy-based Adaptive Controller for Mitigating the Deviations in Wind System

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***Abstract*—In the realm of wind energy systems, the quest for optimal control strategies has led to the exploration of innovative approaches. This study delves into the realm of adaptive control, specifically focusing on a Modified Fuzzy-Based Adaptive Controller designed to mitigate deviations in wind systems. This controller, a product of meticulous investigation, harnesses the power of fuzzy logic with strategic modifications to enhance its adaptability. The proposed controller exhibits a remarkable ability to dynamically adjust its parameters, ensuring optimal performance across diverse operating conditions. Through rigorous experimentation and analysis, the controller's efficacy in mitigating deviations in wind systems has been established, marking a significant advancement in the quest for robust and efficient control strategies. Renewable energy is an ever-changing field, and the Modified Fuzzy-Based Adaptive Controller is a significant advancement. This controller has the ability to adjust parameters dynamically and mitigate deviations in wind systems, which improves the efficiency of wind energy systems and contributes to the broader field of adaptive control. As innovation continues to shape the future of sustainable energy, this controller serves as a testament to the relentless pursuit of a more resilient and environmentally conscious world.**

***Index Terms*— WECS, Fuzzy Logic, PMSG, Fuzzy based Adaptive Controller.**

I. Introduction

In the dynamic arena of renewable energy, pursuing optimal control strategies for wind energy systems has fueled a continuous exploration of inventive methodologies. This research narrative unfolds with a spotlight on adaptive control, honing in on a pioneering solution—the Modified Fuzzy-Based Adaptive Controller. Crafted through a systematic investigative process, this controller emerges as a transformative stride in addressing and rectifying deviations within wind systems. At its conceptual core lies the strategic amalgamation of fuzzy logic, enriched with nuanced modifications that amplify its versatility. This introduction lays the groundwork for an exploration into the intricacies of this controller, spotlighting its prowess in dynamically adapting parameters.
The study showcases the effectiveness of the controller in reducing deviations and optimizing wind energy systems. It advances the field of adaptive control and positions the Modified Fuzzy-Based Adaptive Controller as a key player. This introduction invites readers to a realm where innovation and environmental consciousness come together, guided by the transformative power of this cutting-edge controller.
An effective method to maximize the acquisition of the Maximum Power Point in a direct-driven Permanent

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