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POWER QUALITY IMPROVEMENT USING DYNAMIC VOLTAGE RESTORER-BASED ANFIS CONTROLLER

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ABSTRACT

Network power misfortune and influence quality crumbling are creating many issues, particularly for delicate purposes, for example, server farms, air terminals, medical care, banking, protection, and telecom. These issues should be settled through energy congruity inclusion and enhancement. Dynamic voltage restorers (DVR) are by and large used to moderate organization voltage unsettling influences and keep consistent voltage esteem between load terminals for a short and restricted span because of restricted energy storage spaces. Notwithstanding, this paper's proposed (DVR) framework constrained by the versatile organization fluffy surmising framework (ANFIS) regulator can make up for delayed power quality unsettling influences by incorporating a cross breed sustainable power framework (HRES) oversaw utilizing traditional Corresponding Indispensable (PI) regulator power the executives. This paper proposes a new (DVR) geography combined with a cross breed sustainable power framework (HRES) to take advantage of free and clean energy, comprising of a sunlight based charger, a PEM power device, and a battery stockpiling gadget associated through DC converters to a DC transmission, the got results from the reproduction cycle of the proposed DVR framework in the climate of MATLAB/Simulink showed the capacity to wipe out droop that surpassed 0.9 pu in a time of multiple min and grows that surpassed 1.2 pu in a period that surpassed one moment. In examination, the heap voltage's all out consonant bending THDv was decreased from 29% to 5%, and the source current complete symphonious twisting THDi from 30.25% to 2.79%.

KEYWORDS: *ANFIS.*

Article History

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INTRODUCTION

Reliable and high-quality power supply is crucial in modern electrical distribution systems, especially in areas like data centers, healthcare facilities, and essential infrastructure that require uninterrupted operations. To address ongoing concerns like voltage fluctuations, harmonic distortions, and extended power outages, it is essential to develop creative solutions that not only fix these problems but also support the worldwide shift towards sustainable and resilient energy methods. This study focuses on enhancing power quality in distribution networks, particularly in sensitive businesses where minor voltage fluctuations might have significant impacts. Conventional methods like the Unified Power Flow

Controller (UPFC) are successful in specific situations but can be costly and have operating limitations. This research suggests a new method that integrates a (DVR) system with an Adaptive-Network Fuzzy Inference System (ANFIS) controller, together with a Hybrid Renewable Energy System (HRES).The (DVR) has traditionally been used to mitigate short-term voltage disturbances. However, its inability to handle protracted disruptions has led to the incorporation of an Adaptive Neuro-Fuzzy Inference System (ANFIS) controller. The advanced control technology allows the DVR to adjust in real-time to changing power system conditions, enhancing its ability to maintain stable voltage levels for longer durations. The DVR's synergy with the Adaptive-Network Fuzzy Inference System is improved by integrating (HRES). This combination of solar panels, Proton Exchange Membrane (PEM) fuel cells, and battery storage devices provides a twofold benefit. Firstly, it enhances the power supply, aiding in energy resilience. Furthermore, using clean and renewable energy sources supports sustainability goals by tackling environmental issues linked to traditional power production.

The integrated system utilizes conventional Proportional Integral (PI) controllers to regulate power in the Hybrid Renewable Energy System. The ANFIS controller adjusts the voltage injections from the DVR in real-time to maintain voltage stability in response to power system changes. A hybrid multilevel inverter and Sinusoidal Pulse Width Modulation (SHEPWM) are used to address harmonic distortion problems. The simulation results demonstrate a significant decrease in Total Harmonic Distortion (THD) in both load voltage (THDv) and source current (THDi).

OBJECTIVE

The primary aim of this research initiative is to develop and evaluate an integrated system that combines DVR and controlled by ANFIS with a Hybrid Renewable Energy System (HRES).Improving distribution system power quality is the primary goal of this initiative, with a focus on vulnerable industries like hospitals and data centers. In order to maintain a steady and dependable power supply, it is necessary to reduce voltage fluctuations and harmonic distortions.

A (DVR) system regulated by an Adaptive-Network Fuzzy Inference System (ANFIS) handles extended power outages in distribution networks. Integrating a Hybrid Renewable Energy System (HRES) with solar panels, PEM fuel cells, and battery storage to boost power and sustainability. Use a hybrid multilevel inverter and SHEPWM to reduce harmonic distortions. In case of voltage drops or rises, the ANFIS controller should inject the right amount of voltage to maintain voltage stability. Evaluation of the proposed system's ability to reduce voltage fluctuations and harmonic distortions using MATLAB/Simulink simulations. The suggested DVR system will be compared to current alternatives such the Unified Power Flow Controller (UPFC) for power quality, reliability, and cost.

Methodology

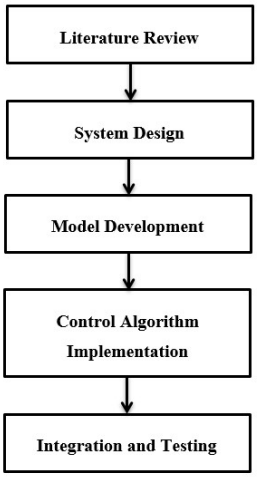

Figure 1

LITERATURE REVIEW

B. Karthik, et.al, 2021, "Design of Using Optimised PSO - ANFIS Controller for Power Quality Improvement", ICTACT Journal on Microelectronics

With quick patterns in the business, power wonderful transforms into vital. Power quality is depicted as any power inconvenience appeared in the voltage, current or recurrence deviations that achieve disappointment or mal normal for the buyer gear. Power quality issues might be classified as speedy period voltage varieties, extended period voltage varieties, waveform mutilations, homeless people, voltage unevenness and voltage flash. Among the various power charming issues, voltage hang, voltage swell and music are additional predominant in the circulation framework. To repay those issues, (DVR) is utilized. DVR is a succession repaying gadget to relieve voltage list and voltage enlarge. It is in like manner utilized as assortment dynamic channel to relieve music. In this work, Demonstrating of the DVR all in all with streamlined ANFIS regulator, have been developed beneath the Matlab/Simulink environmental factors to moderate Voltage droop and sounds in the power framework. PSO tuning geography is followed for improving the ANFIS regulator.

S.Satthiyaraj, et.al, 2019, "for Power Quality Improvement in Distributed Power System by ANFIS Controller", IJEDR

The Power Quality examination ought to give further developed power quality the use of force gadgets to assist power shoppers. The exploration work remembers for profundity investigation of the communication among loads, power organizations and different power quality improvement gadgets. It successively drives to more readily plan of moderation materials like (DVR) to alleviate different power quality related issues. The fundamental goal of this study is to create a model of DVR. DVR is one of the custom power gadgets that are utilized as a useful answer for the security of touchy burdens upon voltage aggravations in power dispersion framework. The execution of the DVR relies upon the accomplishment of the control strategy, which engaged with exchanging of the inverters. The legitimacy of the proposed technique and accomplishment of the ideal remuneration are affirmed by the aftereffects of the reenactment in MATLAB/Simulink. The Versatile Neuro-Fluffy Obstruction (ANFIS) based DVR has been accomplished and it have been checked that its transient reaction is superior to the PI and Fluffy Rationale Regulator reaction.

Abdul Jabbar Fathel Ali, et.al, 2019, "Fuzzy Neural Controller Based Control for Power Quality Improvement", Research & Reviews: Research and Review: Journal of Engineering and Technology

Power quality is a proportion of electrical power productivity which is communicated from the place of age to the purchasers. Power quality is a bunch of boundaries like progression of supply and qualities of voltages like extent, recurrence, balance and waveform. Presently, power quality is an issue that prompts monetary issues. Many studies have been shown that unfortunate power quality makes enormous financial misfortunes modern areas and huge measure of influence is squandered because of influence quality issues like hangs, expands, sounds, gleams and so on. In this paper, the demonstrating and recreation of a (DVR) is accomplished utilizing MATLAB/Simulink. Issues are made with the proposed frameworks, and the unsettling influences are started at length of 0.8 sec till 0.95 sec. Correlation of the exhibitions of the Fluffy brain and Fluffy rationale based DVR are introduced. Results are showed that Fluffy rationale regulator can reestablish the heap voltage to the ostensible worth in both straight and nonlinear loads rapidly and productively. Yet, when the second and third music are superimposed on the voltage hang and voltage enlarge by the use of 3-ph programmable source, the fluffy rationale regulator neglects to reestablish and diminish the consonant substance to OK qualities which is as per IEEE standard 3% for the singular voltage and 5% for the three stage voltage. While the Fluffy brain regulator has been extremely strong and effective to reestablish the heap voltage to the pre-droop worth and make it smooth under various instances of flaws and nonlinear burden conditions and keep the music inside as far as possible in all cases.

Nhlanhla Mbuli, 2023, "as a Solution to Voltage Problems in Power Systems: Focus on Sags, Swells and Steady Fluctuations", MDPI

This paper offers the results of a survey on the use of a (DVR) in power systems to reduce voltage sags, swells, and variations outside steady limits. PRISMA is used to perform and report the review, and Scopus is used to find relevant publications. The survey includes 68 publications. Bibliometric analysis includes annual publications, top 10 most-cited journals, and top 10 most-cited publications. The selected publications' content is retrieved, summarized, and categorized into DVR network scenarios, topologies, and optimisation; DVR controller techniques; and DVR topology and controller feasibility platforms. Additionally, research trends and gaps are assessed. Finally, study topics are suggested. This study covers DVR research on voltage issues and is useful for scholars interested in distributed flexible AC transmission systems (DFACTSs) and DVRs.

PROBLEM DEFINITION

The challenge is to improve power quality in distribution systems, critical for sensitive sectors like data centers and healthcare. Current solutions like the Unified Power Flow Controller (UPFC) have limitations, including high costs and operational constraints. The proposed solution involves a (DVR) controlled by an Adaptive-Network Fuzzy Inference System (ANFIS), coupled with a Hybrid Renewable Energy System (HRES). This aims to mitigate power disturbances and integrate renewable energy for more stable and sustainable power supply. Unlike UPFC focused on transmission, the proposed DVR targets distribution-level power quality improvement.

EXISTING SYSTEM

UPFCs are primarily designed for the transmission level, where they control and optimize power flow, voltage, and impedance. Their application in distribution networks is limited, and they may not effectively address localized power quality issues. The installation and maintenance costs of UPFCs are typically high. Additionally, their operational constraints, such as the need for dedicated space and complex control algorithms, make them less practical for distribution-level power quality improvement. UPFCs may not efficiently adapt to the dynamic nature of distribution systems, especially in scenarios where localized disturbances and voltage fluctuations are frequent. UPFCs do not inherently integrate renewable energy sources, limiting their contribution to sustainability goals. While UPFCs can alleviate certain power quality issues, their focus is often on short-term disturbances, and they may not provide sustained improvements for prolonged power interruptions.

PROPOSED SYSTEM

The proposed system represents an innovative and integrated approach to power quality improvement in distribution systems, with a focus on addressing voltage fluctuations, harmonic distortions, and prolonged power interruptions. The key components of the proposed system include a (DVR) controlled by an Adaptive-Network Fuzzy Inference System (ANFIS), coupled with a Hybrid Renewable Energy System (HRES). The following outlines the key elements of the proposed system:

(DVR)

The DVR serves as the core component for mitigating voltage sags and swells in the distribution network. Traditionally limited by short-duration compensation due to energy storage constraints, the proposed system enhances the DVR's capability to address prolonged disturbances. The DVR is strategically placed in the distribution network to inject the appropriate voltage and maintain a constant voltage level at the load terminals.

BLOCK DIAGRAM

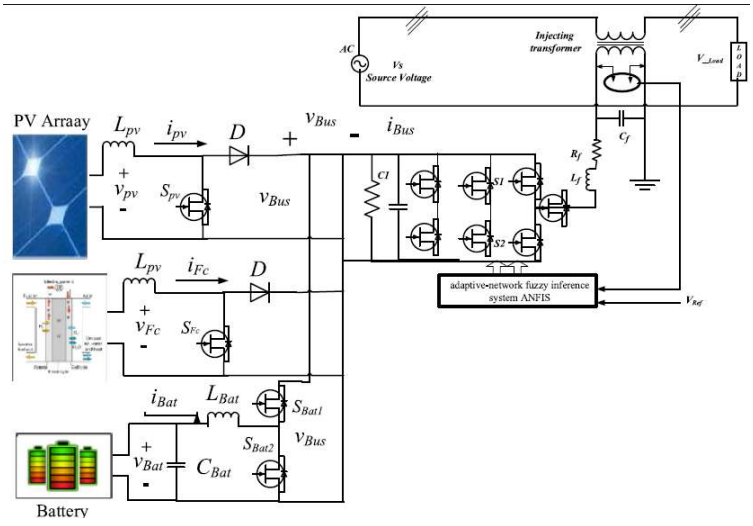

Figure 2

PV PANEL MODEL

The same circuit of a photovoltaic cell is displayed in Fig. 2, which frequently communicates the same circuit graph of a diode model that is relative to the silicon photovoltaic's deliberate current and voltage qualities module. Where the ongoing source Iph addresses the photocurrent of the cell. Rsh and Rs are the cell's natural changes, and series protections are frequently failed to improve on the investigation (Padiarajan and Muthu, 2011). By and by, PV modules are a get together of photovoltaic cells. These modules might be associated in series or resemble to make PV clusters to produce power in photovoltaic power age frameworks.

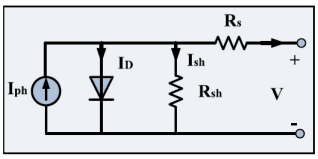

Figure 3

SIMULINK

Dynamical systems can be modeled, simulated, and analyzed with the help of Simulink. It works with continuous-time, sampled-time, and mixed-time models of linear and nonlinear systems. The rate at which a system's many components are sampled or updated might be called its "multi rate." Simulink's GUI allows users to construct models as block diagrams by pointing, clicking, and dragging the mouse. This interface allows you to sketch your models similarly to how they would appear on paper (or in most textbooks). This is a huge improvement over older simulation systems that necessitated custom programming of differential and difference equations. Sinks, sources, linear components, nonlinear components, and connectors are all part of Simulink's extensive block library. Your own unique layouts and blocks can be made.

Once a model is defined, you can run simulations on it using different integration strategies by selecting them from Simulink's menus or by typing them into MATLAB's command window. If you need to conduct multiple simulations at once (say, for Monte Carlo simulations or to sweep a parameter across a range of values), the command-line interface is far more efficient than the menu system. Scopes and other types of display blocks allow you to view the simulation's output in real time. Tools for analyzing models can be found in MATLAB and its application toolboxes, as well as the linearization and trimming tools available from the MATLAB command line. Thanks to the seamless integration between the two programs, you can run simulations, conduct analyses, and make changes to your models without switching environments.

SIMULATION DIAGRAM

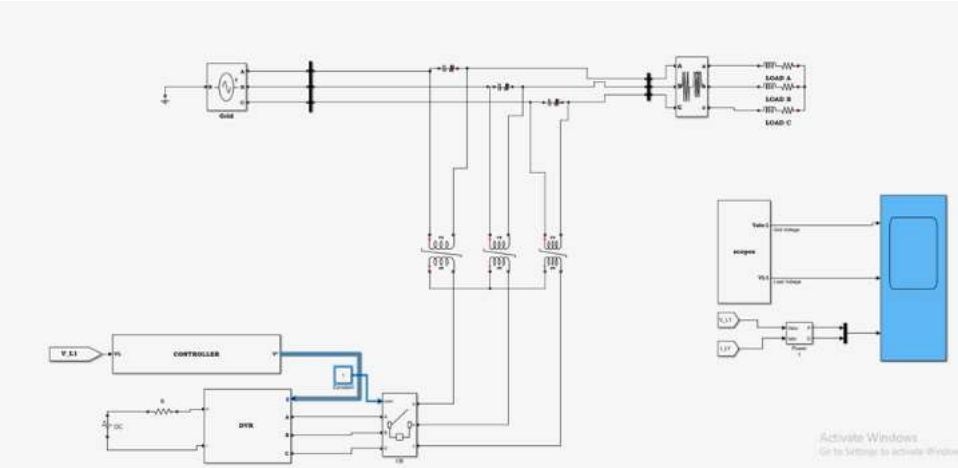

Figure 4

DVR

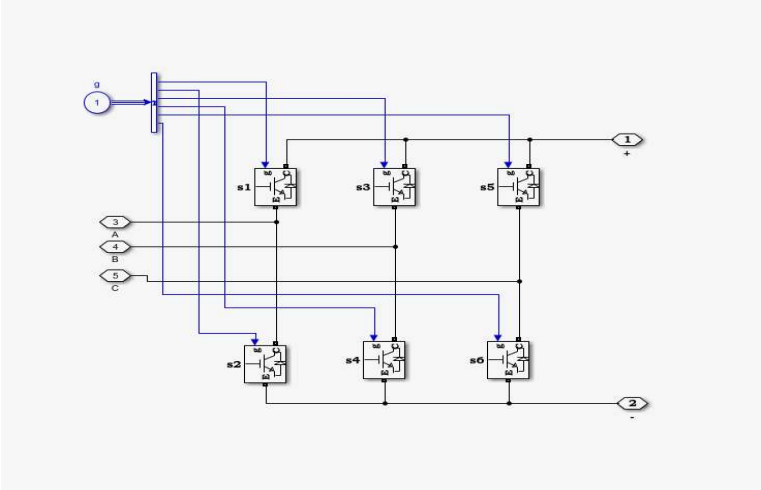

Figure 5

CONTROLLER

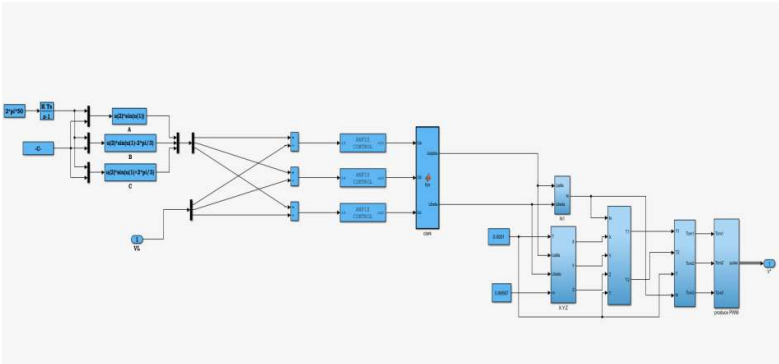

Figure 6

GRID

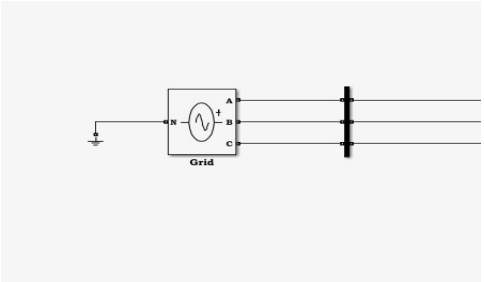

Figure 7

LOAD

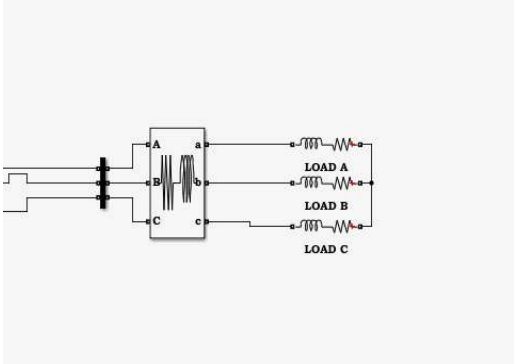

Figure 8

FEEDER INPUT VOLTAGE WITHOUT DVR

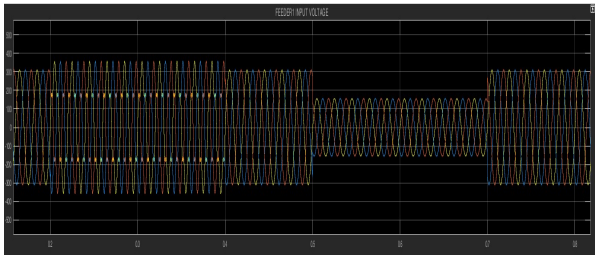

Figure 9

FEEDER OUTPUT VOLTAGE WITHOUT DVR

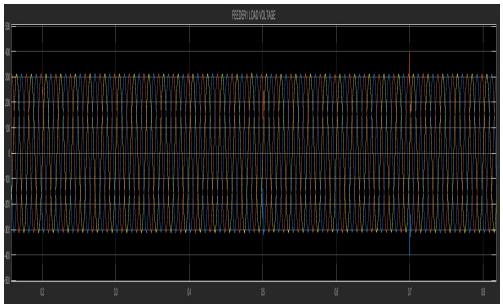

Figure 10

REAL AND REACTIVE POWER WITHOUT DVR

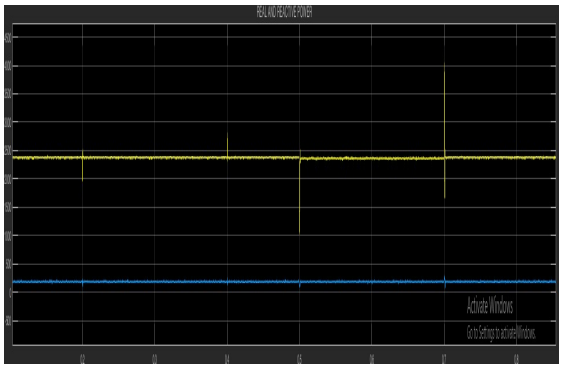

Figure 11

REAL AND REACTIVE POWER WITH DVR

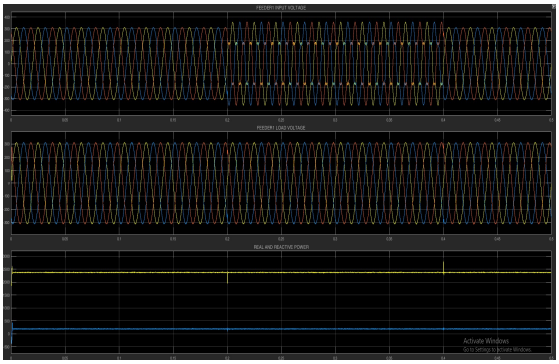

Figure 12

CONCLUSION

This research introduces a forward-looking solution for enhancing power quality in distribution systems by proposing an integrated system that combines a (DVR) controlled by an Adaptive-Network Fuzzy Inference System (ANFIS) with a Hybrid Renewable Energy System (HRES). The synergistic integration of these components has demonstrated promising outcomes, surpassing traditional limitations in mitigating prolonged power disturbances, such as voltage sags and swells. The ANFIS controller's adaptability plays a pivotal role, dynamically adjusting the voltage restoration strategy in response to real-time changes in the distribution network, ensuring a sustained and stable power supply. The incorporation of a HRES, featuring solar panels, Proton Exchange Membrane (PEM) fuel cells, and battery storage devices, not only enhances energy resilience but aligns with global sustainability goals. The optimized control strategy, employing classical Proportional Integral (PI) controllers within the HRES and the dynamic adjustments facilitated by ANFIS, ensures efficient power distribution. Furthermore, the system effectively reduces Total Harmonic Distortion (THD) through the implementation of a hybrid multilevel inverter and Sinusoidal Pulse Width Modulation (SHEPWM). The simulation results in MATLAB/Simulink affirm the proposed system's capability to mitigate voltage fluctuations, minimize harmonic distortions, and sustain a stable power supply over extended periods. In comparison to traditional solutions like the Unified Power Flow Controller (UPFC), the proposed system offers a distribution-focused alternative, emphasizing its unique advantages in terms of power quality improvement, system reliability, and cost-effectiveness. In essence, this integrated system marks a significant stride towards a more resilient, sustainable, and high-quality power supply in distribution

networks, with potential applications in critical sectors demanding uninterrupted and reliable energy. Further empirical validation and real-world implementations will be crucial in substantiating the practical feasibility and effectiveness of the proposed solution.

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