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OPTIMIZING POWER QUALITY: A FUZZY ENABLED APPROACH FOR PV-STATCOM IN GRID INTEGRATED WIND-PV SYSTEM

S Priyadharshini[1] & Dr. Saravanan Kumarasamy[2]

[1]Department of Electrical and Electronics Engineering, Dr. M.G.R Educational Research and Institute, Chennai, India

[2]Professor, Department of Electrical and Electronics Engineering, Dr. M.G.R Educational Research and Institute, Chennai, India

ABSTRACT

The escalating demand for renewable energy sources has prompted extensive exploration into novel applications for meeting global power needs. Power contamination, emerging from contorting or non-direct loads and dispersed age, stays an essential test. This paper introduces a paradigm wherein a Photo-voltaic (PV) Solar Farm operates as a PV-Statcom, synergizing with a Grid-coalesced Wind-PV system to elevate power quality. Custom power gadgets like Stat-com assume a urgent part in killing significant power quality issues like waveform mutilations (music) and responsive power interest. In contrast to conventional approaches employing a Unit Vector Controller, this research employs fuzzy logic as the control strategy for the PV-Statcom. Fuzzy logic controllers are renowned for their adaptability in handling complex, nonlinear systems. The proposed fuzzy logic control strategy offers advantages in terms of dynamic response and adaptability to varying grid conditions. The controller considers multiple input parameters and makes decisions based on linguistic rules, tending to drive quality issues brought about by non-straight loads. The effectiveness of the fuzzy logic-based PV-Statcom control strategy is demonstrated through simulation results using Matlab/Simulink. The outcomes showcase an improvement in power factor and a reduction in Total Harmonic Distortion values, accentuating the capability of fluffy rationale in propelling power quality in matrix coordinated sustainable power frameworks.

KEYWORDS: *PV Solar Farm; PV-Statcom; Power Quality; Wind-PV; Fuzzy Logic; Total Harmonic Distortion.*

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INTRODUCTION

The adoption of renewable energy sources has been increased as a result of the ever-increasing demand for energy, as well as the worldwide necessity to change towards practices that are sustainable and favorable to the environment. The blend of harmless to the ecosystem power systems into current power lattices presents various characteristic issues, despite the fact that these systems, such as Grid-coalesced Wind-PV combinations, make a major contribution to the global energy mix. Non-linear loads and the intermittent nature of distributed generation both create difficulties that might undermine the reliability and stability of the power supply. This exploration researches a clever system to further develop power quality as well as power age. Within the framework of this paradigm, a photovoltaic (PV) solar farm is conceived of as a PV-Statcom that is integrated into a grid-coalesced wind-PV environment. The incorporation of a PV-Stat A new feature is

added to the administration of force quality in environmentally friendly power frameworks with the execution of fluffy rationale as the control technique.com goes beyond the conventional method of solar energy harvesting; it takes an active part in the improvement of power quality within the grid. A new feature is added to the administration of force quality in environmentally friendly power frameworks with the execution of fluffy rationale as the control technique. In order to improve the dynamic responsiveness and flexibility of the PV-Statcom to changing grid conditions, fuzzy logic controllers, which are well-known for their adaptability and capacity to manage complex, non-linear systems, present a possible avenue for improvement. in which we will delve into the methodology, control strategy, and simulation results, demonstrating the effectiveness of the proposed fuzzy logic-based PV-Statcom in improving power quality inside a Grid-coalesced Wind-PV system.

QUALITY ISSUES AND ITS CONSEQUENCES

Power Quality Issues

Power Quality has become a prominent buzzword in the power industry, emphasizing the significance of delivering reliable and stable electrical power. Non-linear loads, which create non-sinusoidal flows, can antagonistically influence the presentation and life expectancy of hardware associated with the electrical lattice. Utility sources such as lightning strikes, equipment faults, and power factor correction devices can introduce disturbances into the power system, compromising its quality. Switching events, including circuit breakers opening and closing, can cause transient disturbances that impact power quality. Addressing power quality issues is essential for ensuring the reliable operation of equipment, minimizing downtime, and optimizing energy efficiency. Continuous monitoring, analysis, and implementation of corrective measures are necessary to maintain satisfactory power quality levels. Investing in technologies like voltage regulation, harmonic filters, and surge protection can help mitigate power quality problems. Collaboration among stakeholders, including utilities, equipment manufacturers, and end-users, is crucial for addressing power quality challenges effectively.

PROPOSED CONCEPT

The proposed system introduces a paradigm shift by incorporating a fuzzy logic-based control strategy in a Photovoltaic (PV) Solar Farm acting as a PV-Statcom within a Grid-coalesced Wind-PV system. Fuzzy logic controllers, known for their adaptability and ability to handle complex, non-linear systems, offer a dynamic and flexible alternative to conventional deterministic control strategies.

The fuzzy logic-based PV-Statcom actively engages in power quality improvement by addressing waveform distortions and reactive power demands. The fuzzy logic controller makes real-time decisions based on linguistic rules and multiple input parameters, allowing for adaptability to changing conditions. This proposed framework plans to improve power factor and lessen Total Harmonic Distortion esteems all the more successfully contrasted with customary methodologies.

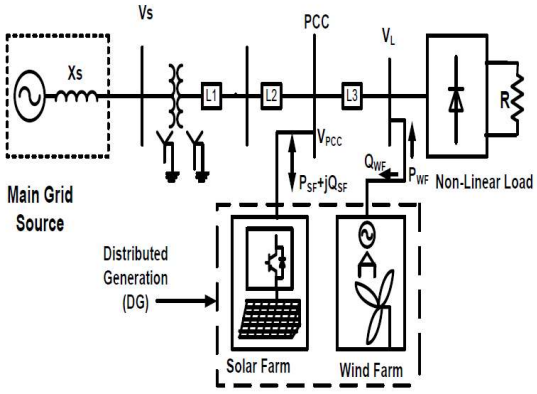

Figure 1: Integrated Wind Solar Grid Tie-System.

METHODOLOGY

The ongoing controlled voltage source inverter based PV Solar Farm acting going about as PV-Statcom can infuses the current into network coordinated Wind-PV framework so that symphonious free current streams in to matrix with wanted size and stage point with separate to fundamental lattice source voltage. To accomplish the characterized focuses on, the proposed framework is carried out to work on the PF, Nature of endlessly power move limit of framework during both constantly at PCC. The matrix coordinated proposed Wind-PV framework comprise Wind Farm (WF), Sun based Homestead proceeding as a PV-Statcom and non-direct burden as displayed in block graph

Wind Farm

In this wind ranch electric power can be made considering variable breeze speed progression with fixed pitch point control turbine. The breeze generator is utilized suitably in light of the fact that it can licenses both predictable and variable weights, which needn't bother with an alternate field circuit and it has run of the mill protection from cut off. The breeze power having with variable nature is tended to as

$$P_{wind} = \frac{1}{2}\rho A V_{wind}^3$$

Where V wind is wind speed (m/s), is air thickness in (Kg/m3) and the region cleared by turbine cutting edge is An in (m2). It is difficult to remove all wind energy into mechanical energy hence it extricate as part of Vwind and it is given as [8].

$$P_{mech} = C_p P_{wind}$$

Where Cp is known as power coefficient, which relies upon type and working state of wind turbine [5]. The definite P Mech is given as

$$P_{mech} = \frac{1}{2}\rho \prod R^2 V_{wind}^3 C_p$$

PV-Statcom

The PV-Statcom is a Solar Farm going about as FACTS regulator like STATCOM for guideline of voltage, PF improvement, and moderation of current music and for responsive power remuneration. It keeps up with DC capacitor voltage steady and persistently infuses or retains dynamic, responsive power into proposed framework at PCC as displayed in Fig.6 to work on the nature of force during constantly time.

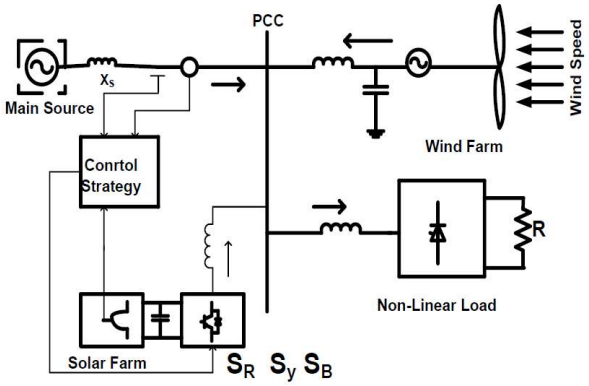

Figure 2: Grid Tie Wind PV System Operation Scheme.

System Operation

The PV-Statcom is associated in the gathering of contorting burden and wind ranch at PCC in the coordinated lattice framework. Mixture or ingestion of dynamic, responsive power is changed by the used controlled scheme. Change of veritable and whimsical power ought to be conceivable with network connect structure to achieve the described targets.

PV-Statcom

A Photovoltaic (PV) STATCOM (Static Synchronous Compensator) is a specific gadget utilized in power frameworks to upgrade the solidness and unwavering quality of the electrical matrix, especially within the sight of sustainable power sources like photovoltaic frameworks. Let's break down the key components and functions of a PV STATCOM:

Fuzzy Logic

Fuzzy logic is a numerical system that arrangements with thinking and dynamic in circumstances where data is loose or unsure. In contrast to traditional twofold rationale (which depends on evident or misleading qualities), Fuzzy logic considers levels of truth to be addressed by values somewhere in the range of 0 and 1. This empowers a more adaptable and nuanced way to deal with taking care of vulnerability.

The key concept in fuzzy logic is the idea of "fuzziness" or "degrees of membership." In old style set hypothesis, a component is either a part or not. Nonetheless, in fluffy rationale, a component can have a place with a set somewhat, going from completely having a place (1) to not having a place by any means (0). This level of participation is communicated as a worth somewhere in the range of 0 and 1.

RESULTS AND DISCUSIONS

The grid integrated Wind-PV framework control plot reenactment results are reproduced utilizing MATLAB/Simulink in Power framework.

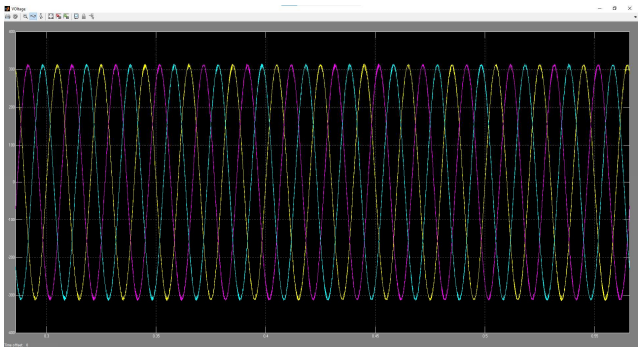

Figure 3: Wind Voltage.

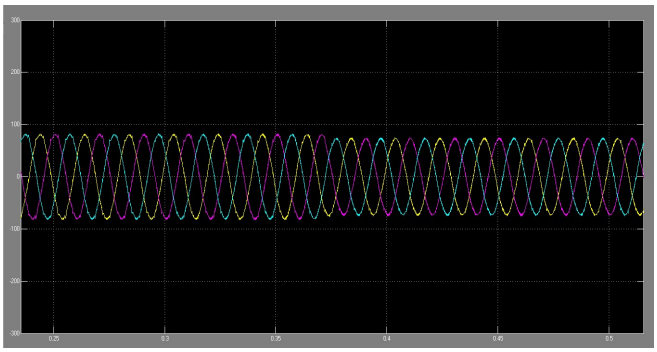

Figure 4: Wind Current.

PV Voltage

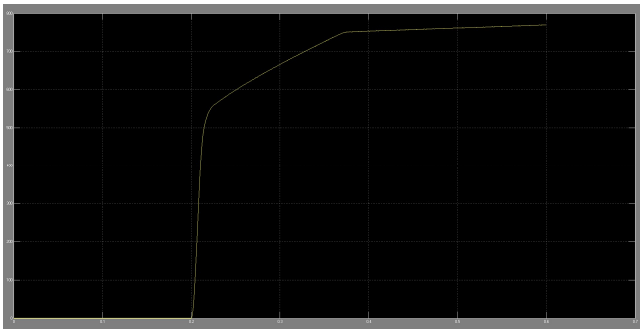

Figure 5: Output of PV Voltage.

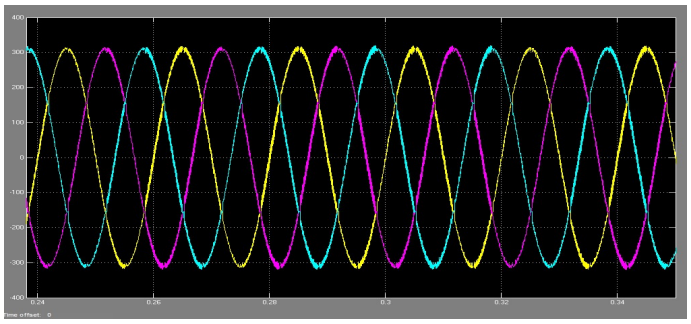

Figure 6: Output of the Load Voltage.

THD

The Fourier examination of source current wave structure with and without channel when PV-Statcom activity is portrayed in fig.7 and fig.8 with its FFT examination. It is obviously seen that with fitting utilization of Sun based Farm as STATCOM the THD valve is diminished from 29.11% to 2.74 %, hence nature of power is moved along.

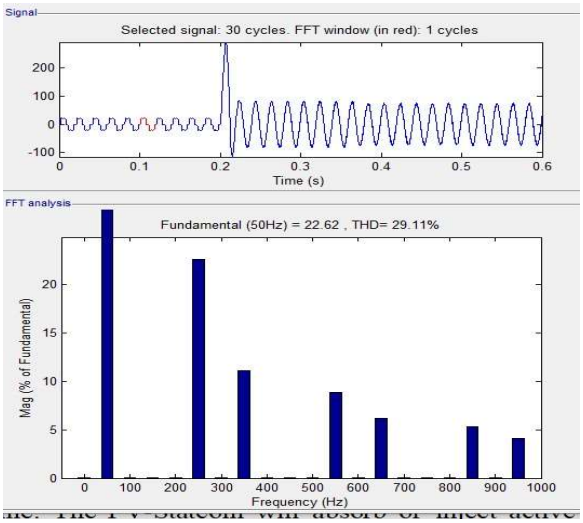

Figure 7: (a) Source Current (b) FFT Source Current without Statcom.

After Statcom

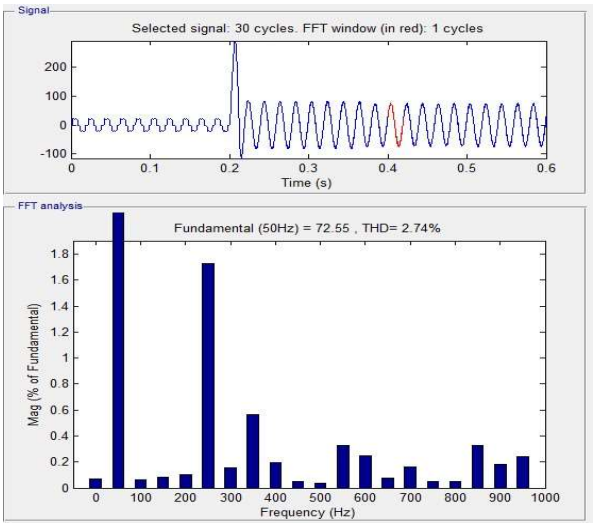

Figure 8: (a) Source Current (b) FFT Source Current with Statcom.

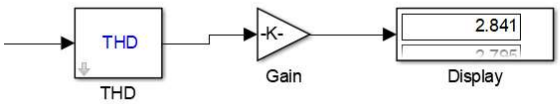

Figure 8: Current THD Display.

CONCLUSION

This research explores a cutting-edge approach to power quality improvement in renewable energy-integrated grids. The transition from a conventional Unit Vector Controller to a fuzzy logic-based control strategy for the PV-Statcom introduces a new dimension in adaptability and responsiveness. Reenactment results utilizing Matlab/Simulink feature the promising presentation of the proposed framework, showing its capability to address power quality difficulties more really than customary techniques. The integration of a PV Solar Farm as a dynamic and adaptable PV-Statcom demonstrates the innovative nature of the proposed system. As the world continues its transition towards sustainable energy solutions, this exploration adds to the developing scene by giving bits of knowledge into the use of fluffy rationale in improving power quality inside lattice mixed environmentally friendly power frameworks. The outcomes of this study pave the way for future implementations and optimizations, fostering a more resilient and reliable renewable energy infrastructure.

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