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Mitigation of Power Quality Issue in Hybrid Renewable Energy Source by UPQC with Optimization Techniques

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ABSTRACT

This paper presents a comprehensive approach to mitigate power quality issues in hybrid renewable energy systems through the utilization of Unified Power Quality Conditioner (UPQC) integrated with optimization techniques. As renewable energy sources like wind and solar play an increasingly significant role in power generation, ensuring high-quality power supply becomes imperative. The UPQC, comprising series and shunt active power filters, is strategically deployed to address voltage fluctuations, harmonics, and other disturbances. To enhance its efficacy, advanced optimization techniques such as control algorithm optimization and parameter tuning are employed. These techniques enable the UPQC to adapt to varying operating conditions and optimize its performance in real-time. Integration with hybrid renewable energy sources is seamless, facilitating coordinated operation for optimal power quality enhancement. The proposed approach emphasizes real-time monitoring and control, enabling proactive response to power quality fluctuations and ensuring stable and reliable electricity supply. Through rigorous testing, validation, and maintenance protocols, the effectiveness and reliability of the integrated system are demonstrated. This holistic approach contribute to the stability and sustainability of modern power grids, fostering the widespread adoption of hybrid renewable energy systems.

Introduction:

Over the recent few years, the integration of renewable energy sources, such as solar power and wind, into the grid has surged significantly, driven by environmental concerns and advancements in technology. While renewable energy offers several advantages, including energy independence and reduced carbon emissions, its intermittent nature poses challenges to the stability and reliability of power systems. One of the critical challenges is the occurrence of power quality issues, such as voltage fluctuations, harmonics, and transient disturbances, which can adversely affect the performance of sensitive equipment and disrupt grid operations.

In order to resolve these concerns with power quality in hybrid renewable energy systems, the Unified Power Quality Conditioner (UPQC) has emerged as a promising solution. The UPQC is a flexible and versatile device that combines series and shunt active power filters to mitigate various power quality disturbances. However, to fully leverage the capabilities of UPQC and optimize its performance, advanced optimization techniques are required.

In this context, this paper focuses on the mitigation of power quality issues in hybrid renewable energy sources through the integration of UPQC with optimization techniques, with a specific emphasis on the Grey Wolf Optimization (GWO) technique. GWO is a nature-inspired metaheuristic algorithm that solves optimization problems quickly by imitating the hunting style of grey wolves.

By combining UPQC with the GWO technique, this research aims to strengthen the effectiveness and efficiency of power quality mitigation in hybrid renewable energy systems. The GWO algorithm will be employed to optimize the control parameters of UPQC in real-time, enabling adaptive and intelligent responses to changing grid conditions. Through this integrated approach, the paper seeks to provide the reliability, stability, and sustainability of modern power systems, paving the way for the widespread adoption of hybrid renewable energy sources.

The subsequent sections of the paper will delve into the theoretical background of UPQC, optimization techniques, and the Grey Wolf Optimization algorithm. Furthermore, the methodology for integrating UPQC with GWO will be outlined, followed by simulation studies and case studies to confirm the suggested strategy's efficacy.

Related Work:

1. **"Unified Power Quality Conditioner: A Comprehensive Review"** (S. Narayanan, K. R. Sasidharan Pillai, 2016): This paper provides a

comprehensive review of Unified Power Quality Conditioners (UPQC), discussing its topology, control strategies, and applications in mitigating various power quality issues. It offers insights into the operational principles and performance evaluation of UPQC in different grid scenarios.

2. **"Power Quality Improvement Using UPQC: A Review"** (V. Agarwal, R. Bhargava, 2015): This review paper discusses the application of UPQC for distribution systems power quality enhancement. It highlights the effectiveness of UPQC in harmonics, swells, mitigating voltage sags, and unbalance, along with various control strategies and optimization techniques.

3. **"Grey Wolf Optimization: A Review of Recent Advances and Applications"** (S. Mirjalili, A. Lewis, 2016): This paper provides an overview of the Grey Wolf Optimization (GWO) algorithm, discussing its principles, benefits, and recent advancements. It reviews various applications of GWO in optimization problems across different domains, highlighting its efficacy and performance.

4. **"Grey Wolf Optimizer-Based Power System Optimization: A Review"** (M. A. Abido, 2018): This review paper focuses on the application of Grey Wolf Optimization (GWO) in power system optimization problems, including economic dispatch, optimal power flow, and parameter tuning of controllers. It discusses the implementation of GWO and its performance compared to other optimization techniques.

5. **"Hybrid Renewable Energy Systems: A Review of Power Quality Issues and Solutions"** (A. M. Gole, A. Joshi, 2019): An overview of power quality problems with hybrid renewable energy systems is given in this work discussing challenges such as voltage fluctuations, harmonics, and transient disturbances. It surveys various solutions, including the integration of UPQC and optimization techniques, to address these power quality issues effectively.

6. **"Optimal Power Quality Enhancement in Renewable Energy Systems using UPQC with Metaheuristic Techniques.

3. Materials and Methods

Power quality improvement for the introduce hybrid renewable energy based distributed system using UPQC is realized through the simulation environment in MATLAB. The renewable farm integrates an 8 kW SPV and 6.6 kW WE system to power the shared DC bus. The grid integrated and DC bus interface with the inverter. The transmission line between the grid and the load is connected to the +/-2 MVA UPQC, respectively. In the suggested electric power system, UPQC is acknowledged as a common active power filter or multifunction power controller.

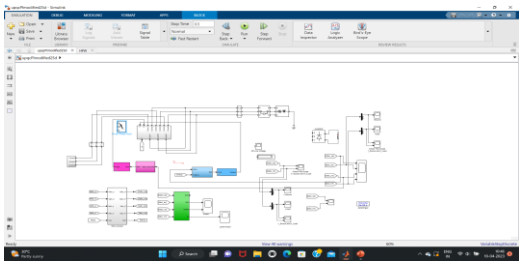

Fig 1 . Circuit for UPQC hybrid system

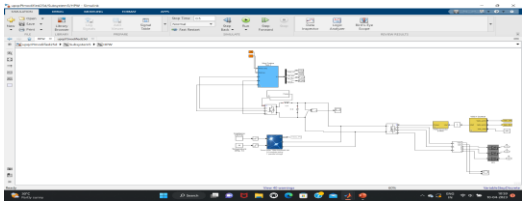

Fig 2 . Circuit for wind solar hybrid system

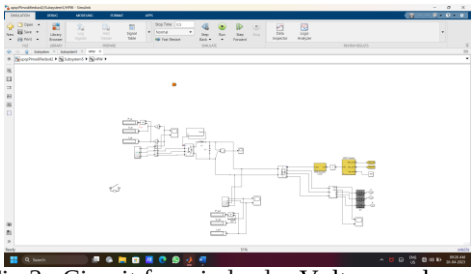

Fig 3 . Circuit for wind solar Voltage and current

In the proposed research, UPQC controls the simulated waveforms more effectively, demonstrating the effects of sag and swell on the grid side parameters. Ultimately, the suggested system's harmonic distortion is brought down to a level that is acceptable.

1. SIMULATION RESULTS AND DI SCUSSI ON

The simulation environment is used to achieve power quality improvement for the suggested hybrid renewable energy-based distributed system utilizing UPQC. The renewable farm's system is interconnected to provide the DC bus. The grid-integrated AC transmission line and the DC bus are interfaced by the inverter. The transmission line that connects the grid and the load, respectively, is where UPQC is attached. On the other hand, problems with power quality such as swell and sag are introduced at the grid side. The suggested system is examined with different wind and irradiation levels.

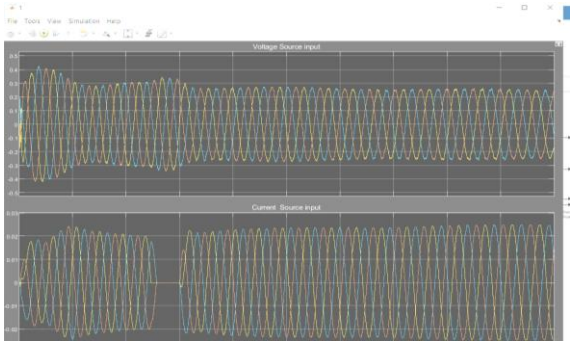

Fig 4 .Output of UPQC hybrid system

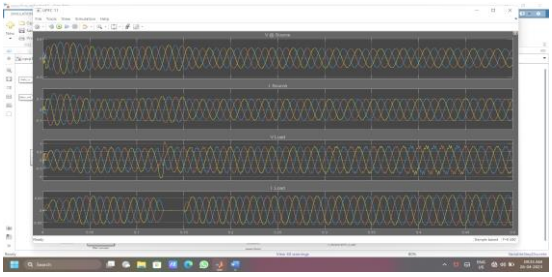

Fig 5 Output at Various Stage

Conclusion:

In conclusion, this paper has explored the mitigation of power quality issues in hybrid renewable energy sources through the integration of the UPQC with optimization techniques, with a specific focus on the GWO algorithm. Integration of optimization techniques such as the GWO algorithm further enhances the performance and efficiency of UPQC. By optimizing control parameters in real-time, GWO enables adaptive responses to changing grid conditions, leading to improved power quality mitigation and system reliability.

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