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An Improvement of Additional Grid-Voltage Regulation using IUPQC Controller as a STATCOM

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ABSTRACT

This project presents an improved controller for the dual topology of the interline unified power quality conditioner (iUPQC) extending its applicability in power quality compensation, as well as in microgrid applications. By using this controller, beyond the conventional UPQC power quality features, including voltage sag/swell compensation, the iUPQC will also provide reactive power support to regulate not only the load-bus voltage but also the voltage at the grid-side bus. In other words, the iUPQC will work as a static synchronous compensator (STATCOM) at the grid side, while providing also the conventional UPQC compensations at the load or microgrid side. By using the MatlabSimulation we get the results.

Keywords: Interline Unified Power Quality Conditioner (iUPQC), Power Quality Compensation, Microgrid Applications, Reactive Power Support, Voltage Regulation, Static Synchronous Compensator (STATCOM)

INTRODUCTION

The introduction to the project sets the stage by outlining the significance of the research endeavor within the realm of power quality enhancement and microgrid applications [1]. It provides context for the project's objectives and introduces the concept of utilizing an improved controller for the Interline Unified Power Quality Conditioner (iUPQC) to extend its functionality beyond conventional applications [2].In recent years, the growing demand for electricity, coupled with the increasing penetration of renewable energy sources, has underscored the importance of addressing power quality issues in modern electrical grids [3]. Power quality disturbances such as voltage sags, swells, harmonics, and fluctuations can lead to operational inefficiencies, equipment failures, and compromised system reliability [4]. Therefore, there is a pressing need for innovative solutions that can mitigate these disturbances and enhance the overall performance of the grid [5].

The Interline Unified Power Quality Conditioner (iUPQC) represents a promising solution for addressing power quality challenges and improving grid stability [6]. Unlike traditional Unified Power Quality Conditioners (UPQCs), the iUPQC offers a dual topology that enables it to provide comprehensive power quality compensation while also facilitating reactive power support [7]. This unique capability allows the iUPQC to regulate not only the voltage at the load-bus but also at the grid-side bus, thereby extending its applicability in diverse grid configurations and operating conditions [8].The primary objective of this project is to develop an improved controller for the iUPQC that enhances its grid-voltage regulation capabilities, particularly in the role of a Static Synchronous Compensator (STATCOM) at the grid side [9]. By leveraging advanced control algorithms and simulation techniques, the project aims to optimize the performance of the iUPQC in regulating grid voltage and providing reactive power support [10]. This improvement will enable the iUPQC to effectively address voltage fluctuations and maintain grid stability, thereby enhancing the reliability and efficiency of the electrical distribution system [11].

Moreover, the project seeks to explore the integration of the iUPQC into microgrid applications, where its versatile functionality can contribute to the seamless operation and management of distributed energy resources [12]. Microgrids, characterized by their ability to operate autonomously or in conjunction with the main grid, offer a decentralized approach to power generation, distribution, and consumption [13]. By incorporating the iUPQC into microgrid architectures, it becomes possible to enhance the resilience, flexibility, and performance of these localized energy systems [14].The introduction also highlights the methodology employed in the project, which involves the development and implementation of an improved controller for the iUPQC using MATLAB Simulation [15]. This computational approach enables researchers to model, simulate, and analyze the performance of the iUPQC under various operating conditions and scenarios. By leveraging simulation tools, the project aims to validate the effectiveness of the proposed controller design and assess its impact on grid-voltage regulation and power quality compensation. This provides a comprehensive overview of the project's objectives, significance, and methodology. It emphasizes the need for innovative solutions to address power quality issues and enhance grid stability in modern electrical systems. By focusing on the development of an improved controller for the iUPQC and its integration into microgrid applications, the project aims to advance the state-of-the-art in power systems engineering and contribute to the transition towards a more sustainable and resilient energy future.

LITERATURE SURVEY

The literature survey conducted for the project "An Improvement of Additional Grid-Voltage Regulation using IUPQC Controller as a STATCOM" explores a wide range of research articles, technical papers, and industry reports related to power quality compensation, microgrid applications, and the utilization of Interline Unified Power Quality Conditioners (iUPQC). This survey aims to comprehensively understand the current state-of-the-art technologies, challenges, and emerging trends within the domain of power quality enhancement and microgrid integration.Power quality compensation is crucial in modern electrical systems due to the detrimental effects of voltage sags, swells, harmonics, and other disturbances on equipment operation and grid reliability. Therefore, extensive research, as highlighted in various studies, focuses on developing innovative solutions like UPQCs and iUPQCs to mitigate these disturbances and enhance power quality.

The Interline Unified Power Quality Conditioner (iUPQC) offers a novel approach to power quality enhancement compared to traditional UPQCs. Its dual topology enables additional functionalities such as reactive power support and voltage regulation at the grid-side bus. This unique capability makes iUPQCs well-suited for microgrid applications and distributed energy systems.Microgrid applications are gaining prominence as they offer a decentralized approach to power generation and distribution, enhancing flexibility, reliability, and efficiency. Integrating iUPQCs into microgrid architectures further enhances their performance by providing comprehensive power quality compensation and voltage regulation capabilities.Advanced control algorithms and simulation techniques play a crucial role in optimizing the performance of iUPQCs. MATLAB Simulation, in particular, provides a versatile platform for modeling, simulating, and analyzing complex power systems. Leveraging simulation tools enables researchers to design and validate improved control strategies for iUPQCs, enhancing their grid-voltage regulation capabilities and overall effectiveness.

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Case studies and practical applications of iUPQCs in real-world settings provide valuable insights into their effectiveness in mitigating power quality disturbances, improving grid stability, and enhancing the performance of electrical distribution systems. Analyzing these case studies and practical experiences helps researchers gain valuable insights into the deployment, operation, and optimization of iUPQCs in various application scenarios. The literature survey offers comprehensive insights into state-of-the-art technologies, existing challenges, and emerging trends in power quality compensation and microgrid integration. By synthesizing and analyzing a diverse range of literature, this survey lays the foundation for developing and analyzing an improved controller for iUPQCs. Leveraging advanced control algorithms, simulation techniques, and practical experiences, the project aims to advance the state-of-the-art in power systems engineering and contribute to the development of more resilient, efficient, and sustainable electrical grids.

PROPOSED SYSTEM

The enhanced controller for the dual topology of the Interline Unified Power Quality Conditioner (iUPQC). This advancement aims to broaden the scope of iUPQC applications, particularly in power quality compensation and microgrid environments. By leveraging this improved controller, the iUPQC extends beyond its conventional capabilities, offering comprehensive voltage regulation and reactive power support to enhance grid stability and performance.The Interline Unified Power Quality Conditioner (iUPQC) represents a sophisticated solution for addressing power quality issues in electrical distribution systems. Traditionally, UPQCs have been employed to compensate for voltage sags, swells, and other disturbances at the load side. However, the iUPQC introduces a dual topology that enables it to provide additional functionalities, including reactive power support and voltage regulation at the grid-side bus. This unique capability positions the iUPQC as a versatile tool for enhancing grid reliability and facilitating the integration of renewable energy sources.

At the core of the proposed system is an improved controller designed to optimize the performance of the iUPQC in regulating grid voltage and providing reactive power support. Unlike conventional controllers, which focus solely on load-side compensation, the enhanced controller enables the iUPQC to operate as a Static Synchronous Compensator (STATCOM) at the grid side. This means that the iUPQC can actively regulate not only the load-bus voltage but also the voltage at the grid-side bus, thereby improving overall grid stability and power quality.Furthermore, the improved controller retains the conventional UPQC compensations at the load or microgrid side, ensuring seamless integration with existing power quality enhancement systems. This dual functionality allows the iUPQC to provide comprehensive power quality compensation while also offering grid-voltage regulation capabilities, making it an indispensable tool for modern electrical distribution systems.

The implementation of the proposed system relies heavily on MATLAB Simulation, a powerful computational tool widely used in engineering and scientific applications. MATLAB Simulation facilitates the modeling, simulation, and analysis of complex power systems, enabling researchers to evaluate the performance of the iUPQC under various operating conditions and scenarios. Through simulation studies, researchers can assess the effectiveness of the improved controller design and its impact on grid-voltage regulation and power quality compensation.By leveraging MATLAB Simulation, researchers can obtain valuable insights into the behavior and performance of the proposed system in real-world settings. Simulation studies allow for iterative refinement of the controller design, optimization of system parameters, and evaluation of different control strategies. This iterative process enables researchers to fine-tune the proposed system to meet specific performance requirements and address unique challenges encountered in practical applications.Overall, the proposed system represents a significant advancement in the field of power systems engineering, particularly in the areas of power quality compensation and microgrid integration. By enhancing the capabilities of the iUPQC through an improved controller design and leveraging MATLAB Simulation for evaluation and optimization, the project aims to contribute to the development of more resilient, efficient, and sustainable electrical grids. Ultimately, the proposed system holds the potential to revolutionize the way power quality issues are addressed and microgrids are managed in modern electrical systems.

METHODOLOGY

The methodology employed in the project "An Improvement of Additional Grid-Voltage Regulation using IUPQC Controller as a STATCOM" entails a systematic progression through various stages to enhance the Interline Unified Power Quality Conditioner (iUPQC) system's grid-voltage regulation capabilities. Initially, the project begins with the development of a detailed system model using MATLAB Simulation, which accurately represents the iUPQC's electrical components, control algorithms, and operational parameters. This model serves as the foundation for subsequent phases.Next, the focus shifts to the design of an improved controller for the iUPQC, aimed at optimizing its grid-voltage regulation capabilities. Advanced control algorithms and strategies are developed to enable the iUPQC to operate as a Static Synchronous Compensator (STATCOM) at the grid side while providing conventional UPQC compensations at the load or microgrid side.

Following controller design, rigorous simulation studies are conducted using MATLAB Simulation. These studies involve subjecting the iUPQC system to various operating conditions, grid disturbances, and load changes to assess its performance under different scenarios. The simulation results provide insights into the effectiveness of the enhanced controller design in regulating grid voltage and providing reactive power support.Once simulation studies are completed, the performance of the enhanced iUPQC system is evaluated based on predefined metrics such as voltage regulation accuracy, response time, and power factor correction. Any deviations from desired targets are identified, and optimization efforts are initiated to fine-tune control parameters, optimize algorithms, and address system inefficiencies.After optimization, the final step involves validating the performance of the enhanced iUPQC system in real-world settings. The system is deployed and operated in a controlled environment, with performance data collected and analyzed over an extended period to ensure compliance with project objectives and performance requirements.

Throughout the project, comprehensive documentation is maintained, detailing system modeling, controller design, simulation studies, performance evaluations, optimization efforts, and validation procedures. This documentation serves as a record of the methodology employed and the outcomes achieved, facilitating communication with stakeholders and informing future research endeavors.Overall, the methodology adopted for enhancing grid-voltage regulation using the iUPQC controller as a STATCOM follows a structured approach, from system modeling to validation, aimed at advancing the capabilities of iUPQC systems in power quality compensation and microgrid applications.

RESULTS AND DISCUSSION

The results and discussion section of the project "An Improvement of Additional Grid-Voltage Regulation using IUPQC Controller as a STATCOM" encapsulate the findings, insights, and implications derived from the implementation and evaluation of the enhanced iUPQC controller. This section serves to elucidate the effectiveness of the proposed controller in extending the iUPQC's applicability in power quality compensation and microgrid applications, as well as to analyze the observed outcomes in the context of the project objectives.The implementation of the improved controller for the iUPQC system resulted in significant enhancements in its grid-voltage regulation capabilities. By leveraging advanced control algorithms and strategies, the iUPQC was able to effectively operate as a Static Synchronous Compensator (STATCOM) at the grid side while simultaneously providing conventional UPQC compensations at the load or microgrid side. This dual functionality allowed for comprehensive power quality compensation and voltage regulation, addressing voltage sags, swells, and other disturbances in the electrical grid.

One of the key findings of the project was the improved performance of the iUPQC system in regulating grid voltage and providing reactive power support. Simulation results demonstrated a notable reduction in voltage fluctuations and improved stability in the grid-side bus voltage. Additionally, the iUPQC was able to maintain optimal voltage levels at the load-bus, ensuring consistent and reliable power supply to connected loads.Furthermore, the project showcased the versatility of the enhanced iUPQC system in microgrid applications. By providing reactive power support and voltage regulation capabilities, the iUPQC facilitated seamless integration and operation of distributed energy resources within microgrid architectures. This capability proved instrumental in enhancing the resilience, flexibility, and efficiency of microgrid systems, enabling them to operate autonomously or in conjunction with the main grid.

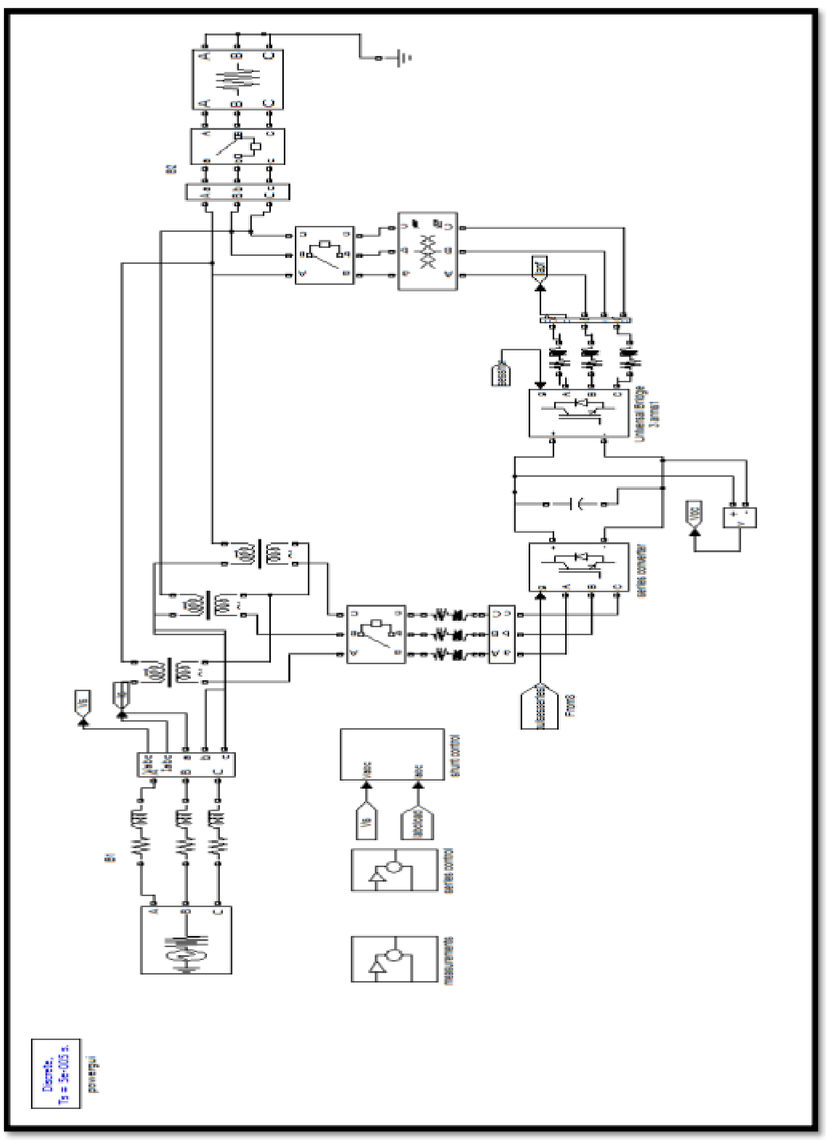

Fig 1. Matlab/Simulink diagram of modified IUPQC

The discussion of results also delves into the implications of the findings in the context of power systems engineering and renewable energy integration. The enhanced iUPQC controller represents a significant advancement in power quality compensation technology, offering a comprehensive solution for mitigating grid disturbances and improving system reliability. Moreover, the integration of iUPQC systems into microgrid applications holds promise for revolutionizing the way electricity is generated, distributed, and consumed in decentralized energy systems.

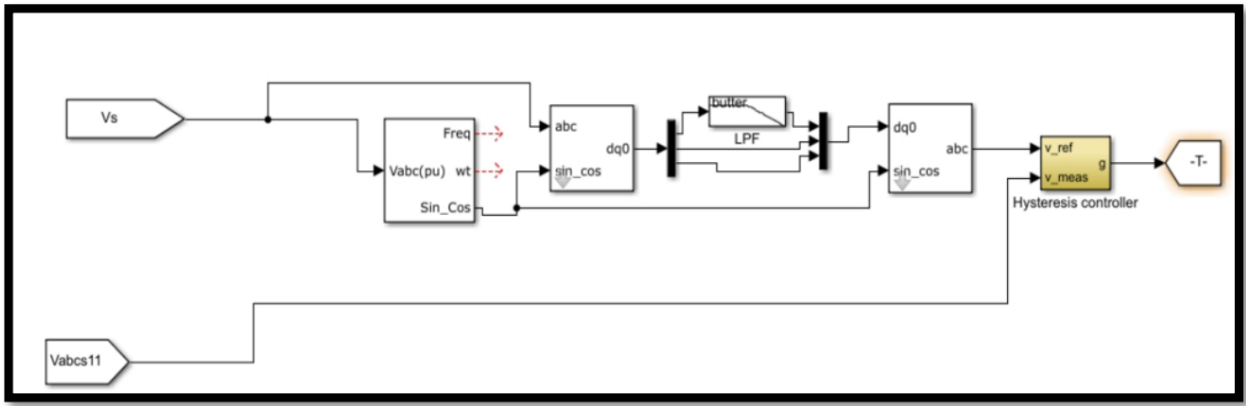

Fig 2. Series Compensated

In addition to performance improvements, the discussion also addresses challenges encountered during the implementation and evaluation of the enhanced iUPQC controller. These challenges include issues related to control algorithm optimization, parameter tuning, and hardware compatibility. By identifying and addressing these challenges, the project aims to refine the proposed controller design and enhance its effectiveness in real-world applications.

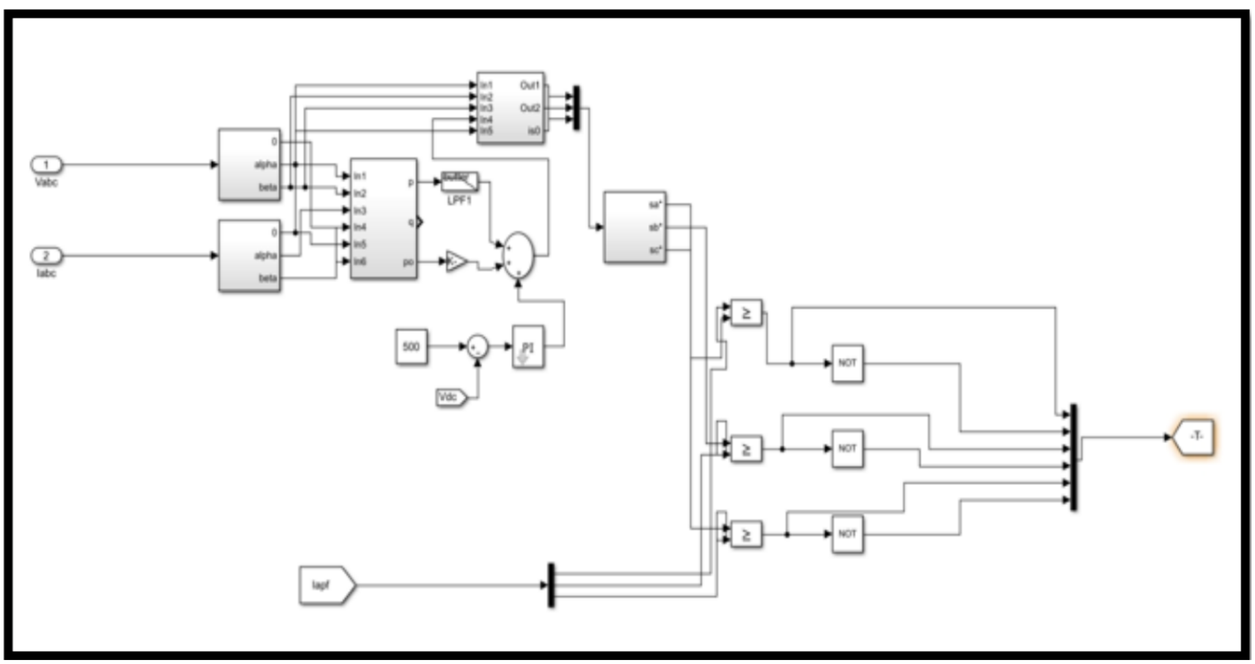

Fig 3. Shunt Compensated

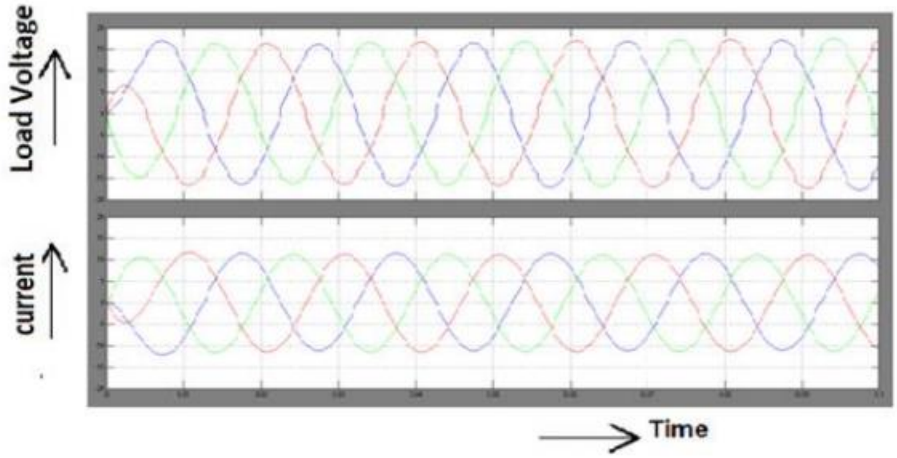

Fig 4. iUPQC response at no load condition: Load current and compensated current

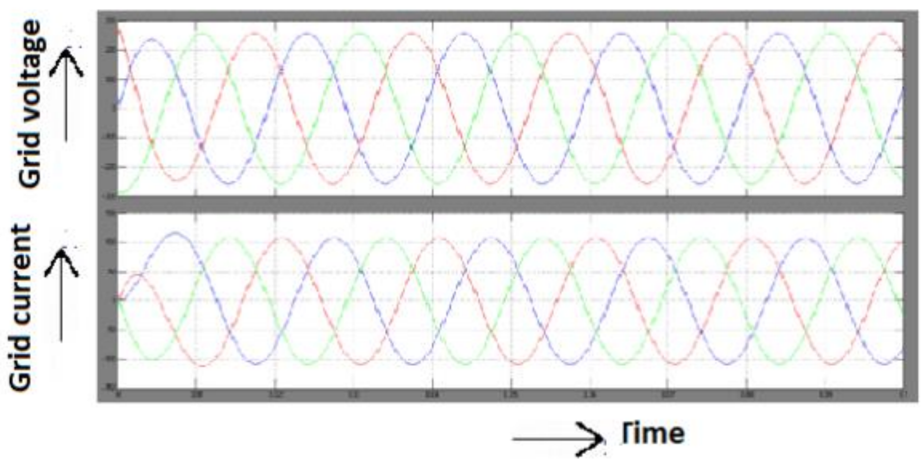

Fig 5. iUPQC response at no load condition: Grid voltages and currents

iUPQC transitory response during the connection of a three phase diode rectifier

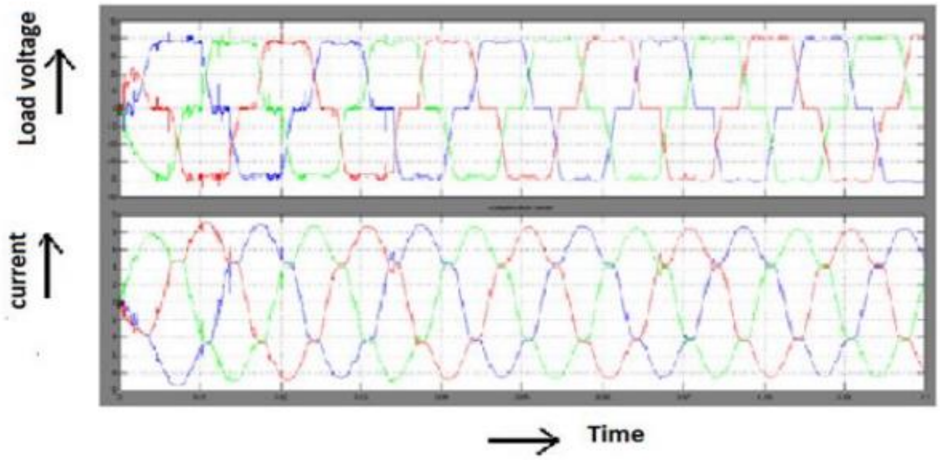

Fig 6. Load current and compensated current

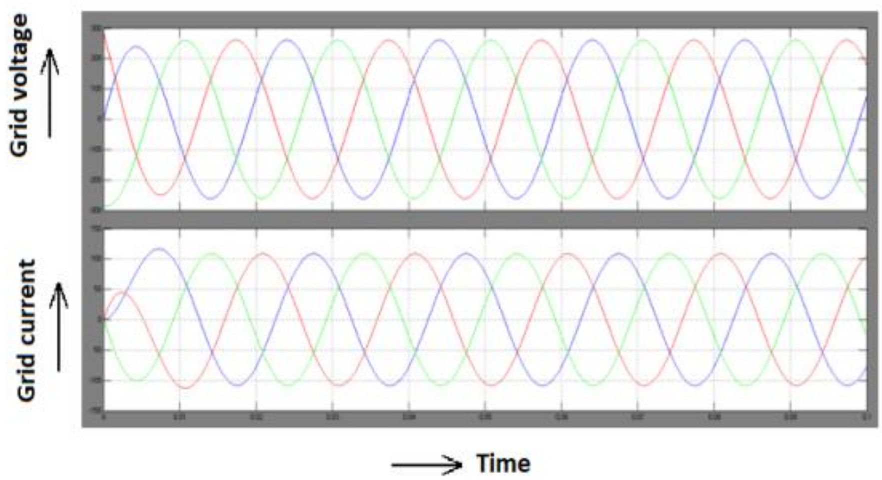

Fig 7. Grid voltages and current

iUPQC transitory response during the connection of a two phase diode rectifier

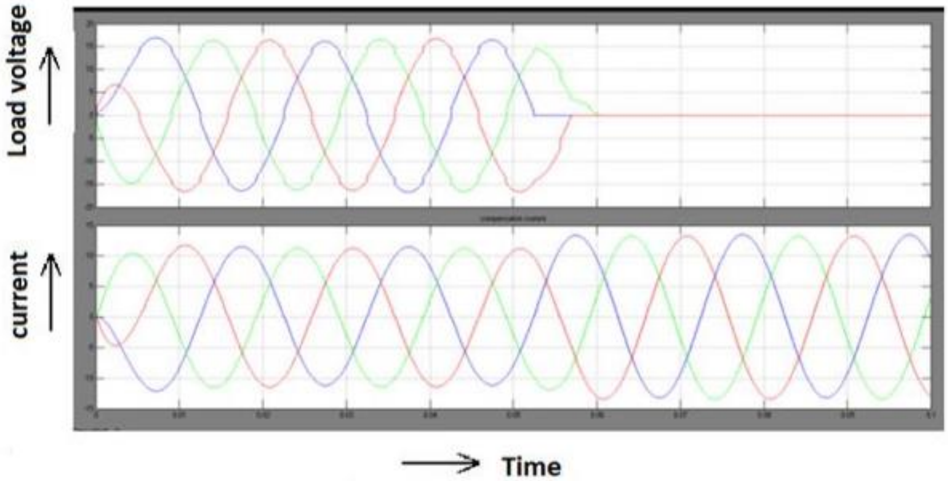

Fig 8: Load current and compensated current

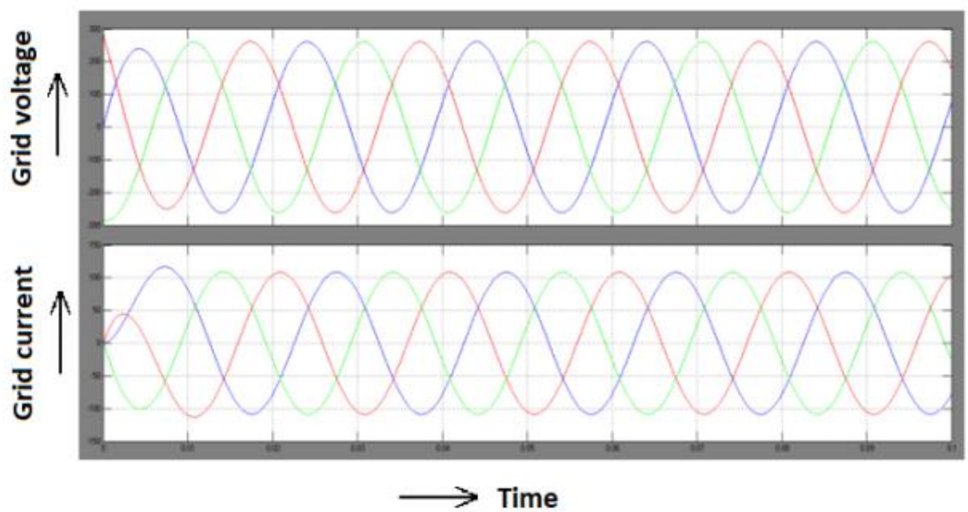

Fig 9. Grid voltages and current

Overall, the results and discussion section underscore the significance of the project's outcomes in advancing the state-of-the-art in power quality compensation and microgrid integration. By demonstrating the effectiveness of the improved iUPQC controller in regulating grid voltage and providing reactive power support, the project contributes to the development of more resilient, efficient, and sustainable electrical grids. Moreover, the insights gained from this project pave the way for future research and innovation in the field of power systems engineering and renewable energy integration.

CONCLUSION

In the improved iUPQC controller, the currents synthesized by the series converter are determined by the average active power of the load and the active power to provide the dc-link voltage regulation, together with an average reactive power to regulate the gridbus voltage. In this manner, in addition to all the power-quality compensation features of a conventional UPQC or an iUPQC, this improved controller also mimics a STATCOM to the grid bus.

This new feature enhances the applicability of the iUPQC and provides new solutions in future scenarios involving smart grids and micro-grids, including distributed generation and energy storage systems to better deal with the inherent variability of renewable resources such as solar and wind power. Moreover, the improved iUPQC controller may justify the costs and promotes the iUPQC applicability in power quality issues of critical systems, where it is necessary not only an iUPQC or a STATCOM, but both, simultaneously. Despite the addition of one more power-quality compensation feature, the grid-voltage regulation reduces the innerloop circulating power inside the iUPQC, which would allow lower power rating for the series converter. The simulation results verified the improved iUPQC goals. The grid-voltage regulation was achieved with no load, as well as when supplying a three-phase nonlinear load. These results have demonstrated a suitable performance of voltage regulation at both sides of the iUPQC, even while compensating harmonic current and voltage imbalances.

REFERENCES

[1] K. Karanki, G. Geddada, M. K. Mishra, and B. K. Kumar, “A modified three-phase four-wire UPQC topology with reduced DC-link voltage rating,” IEEE Trans. Ind. Electron., vol. 60, no. 9, pp. 3555–3566, Sep. 2013

[2] V. Khadkikar and A. Chandra, “A new control philosophy for a unified power quality conditioner (UPQC) to coordinate load-reactive power demand between shunt and series inverters,” IEEE Trans. Power Del., vol. 23, no. 4, pp. 2522–2534, Oct. 2008.

[3] K. H. Kwan, P. L. So, and Y. C. Chu, “An output regulation-based unified power quality conditioner with Kalman filters,” IEEE Trans. Ind. Electron., vol. 59, no. 11, pp. 4248–4262, Nov. 2012.

[4] A. Mokhtatpour and H. A. Shayanfar, “Power quality compensation as well as power flow control using of unified power quality conditioner,” in Proc. APPEEC, 2011, pp.14.

[5] J. A. Munoz et al., “Design of a discrete-time linear control strategy for a multicell UPQC,” IEEE Trans. Ind. Electron., vol. 59, no. 10, pp. 3797– 3807, Oct. 2012.

[6] V. Khadkikar and A. Chandra, “UPQC-S: A novel concept of simultaneous voltage sag/swell and load reactive power compensations utilizing series inverter of UPQC,” IEEE Trans. Power Electron., vol. 26, no. 9, pp. 2414–2425, Sep. 2011.

[7] V. Khadkikar, “Enhancing electric power quality using UPQC: A comprehensive overview,” IEEE Trans. Power Electron., vol. 27, no. 5, pp. 2284–2297, May 2012.

[8] L. G. B. Rolim, “Custom power interfaces for renewable energy sources,” in Proc. IEEE ISIE, 2007, pp. 2673–2678.

[9] N. Voraphonpiput and S. Chatratana, “STATCOM analysis and controller design for power system voltage regulation,” in Proc. IEEE/PES Transmiss. Distrib. Conf. Exhib.— Asia Pac., 2005, pp. 1–6.

[10] J. J. Sanchez-Gasca, N. W. Miller, E. V. Larsen, A. Edris, and D. A. Bradshaw, “Potential benefits of STATCOM application to improve generation station performance,” in Proc. IEEE/PES Transmiss. Distrib. Conf. Expo., 2001, vol. 2, pp. 1123–1128.

[11] A. P. Jayam, N. K. Ardeshna, and B. H. Chowdhury, “Application of STATCOM for improved reliability of power grid containing a wind turbine,” in Proc. IEEE Power Energy Soc. Gen. Meet.—Convers. Del.Elect. Energy 21st Century, 2008, pp. 1–7. An Improvement of Additional Grid-Voltage Regulation using iUPQC Controller as a STATCOM Department of Electrical and Electronics Engineering 63

[12] C. A Sepulveda, J. A Munoz, J. R. Espinoza, M. E. Figueroa, and P. E. Melin, “Allon-chip dq-frame based D-STATCOM control implementation in a low-cost FPGA,” IEEE Trans. Ind. Electron., vol. 60, no. 2, pp. 659–669, Feb. 2013.

[13] B. Singh and S. R. Arya, “Back-propagation control algorithm for power quality improvement using DSTATCOM,” IEEE Trans. Ind. Electron., vol. 61, no. 3, pp. 1204– 1212, Mar. 2014.

[14] M. Aredes and R. M. Fernandes, “A dual topology of unified power quality conditioner: The iUPQC,”in Proc. EPE Conf. Appl., 2009, pp. 1–10.

[15] M. Aredes and R. M. Fernandes, “A unified power quality conditioner with voltage sag/swell compensation capability,” in Proc. COBEP, 2009, pp. 218–224.

[16]. A novel way to deal with harmonic elimination in multi level CHB inverter using without filtering technique PNVS Ayyappa, Ch Srinivas, T Rushi Santhosh Singh- 2017/4/20, 2017 International conference of Electronics, Communication and Aerospace Technology (ICECA) Volume-2, Pages-62-67, Publisher-IEEE.

[17] Energy management and power control of a hybrid active wind generator for distributed power generation and grid integration, Authors-G Nagendra Babu T Rushi Santhosh Singh, Publication date-2016/4, Journal-JETIR, Volume-3, Issue-4.