ISSN: 2454-9940

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

E-Mail :
editor.ijasem@gmail.com
editor@ijasem.org

www.ijasem.org

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

ISSN2454-9940

www.ijasem.org

Vol 18, Issue.2 April 2024

VOLTAGE SAG ENHANCEMENT OF GRID CONNECTED HYBRID PV-WIND POWER SYSTEM USING BES AND SMES BASED DYNAMIC VOLTAGE RESTORER

[1]DR CH.HARIPRASAD, [2]DR B.VIJAY KRISHNA, [3]J.AKSHAYA, [4]B.BHANU PRAKASH, [5]A.MANI KISHORE
[12]ASSISTANT PROFESSOR, [345]B.Tech Students,
Dept of EEE
BAPATLA ENGINEERING COLLEGE

ABSTRACT

The series connected DVR will inject three-phase compensating voltages through the three-phase injection transformer or three single-phase injection transformers with the main supply. The filtered VSI output voltage is boosted to the desired level with the injection transformer. The transformer also isolates the DVR circuit from the distribution system. The capacity of the voltage source inverter (VSI) and the values for the link filter connected between the injection transformer and the inverter play a crucial in the design of the DVR. In this research project, new Dynamic Voltage Restorer (DVR) topology has been proposed. The capacity of the voltage source inverter (VSI) and values of the link filter is small that will improve the compensation capabilities for voltage harmonic, swell and voltage sag mitigation under various fault conditions. The new RLC filter is able to eliminate the switching harmonics. The capacity of the dc supply voltage is reduced when the value of inductance is small. The new DVR topology has high efficiency and the ability to improve the quality of voltage. An outline architecture of the RLC filter parameters for the specific model has been presented. The new DVR with proposed controlled Dynamic Voltage Restorer topology is modelled and simulated using the MATLAB. The control scheme has good control dynamics with minimum transient current overshoot. The simulation results under transient performance are good.

Keywords: Series connected DVR, Three-phase compensating voltages, Voltage source inverter (VSI), Link filter, RLC filter, MATLAB simulation, Control scheme

INTRODUCTION

In the contemporary energy landscape, the integration of renewable energy sources such as photovoltaic (PV) and wind power systems into the grid has gained significant momentum due to their sustainability and environmental benefits [1]. However, the intermittent nature of these sources poses challenges to grid stability, particularly concerning voltage sag occurrences [2]. Voltage sags, characterized by a temporary reduction in voltage magnitude, can disrupt sensitive equipment, leading to operational inefficiencies and economic losses [3]. To address these challenges, Dynamic Voltage Restorers (DVRs) have emerged as effective solutions for mitigating voltage sags and improving power quality [4]. Conventionally, DVRs inject compensating voltages into the grid to restore voltage levels during sag events [5]. However, existing DVR topologies often encounter limitations in terms of compensation capabilities, efficiency, and control dynamics [6].

In response to these limitations, this research project proposes a novel DVR topology tailored for enhancing the voltage sag resilience of grid-connected hybrid PV-wind power systems [7]. Unlike traditional DVR configurations, the proposed topology integrates Battery Energy Storage (BES) and Superconducting Magnetic Energy Storage (SMES) systems to bolster compensation capabilities and efficiency [8]. The core of the proposed DVR topology lies in its innovative architecture, characterized by a series-connected configuration and optimized VSI capacity coupled with a small link filter [9]. This design choice enables improved compensation for voltage harmonics, swells, and sags across various fault conditions [10]. Moreover, the integration of a new RLC filter facilitates the elimination of switching harmonics, further enhancing power quality [11].

A pivotal aspect of the proposed DVR topology is its high efficiency and ability to enhance voltage quality while minimizing the capacity of the DC supply voltage, particularly through the manipulation of inductance values

ISSN2454-9940

www.ijasem.org

Vol 18, Issue.2 April 2024

[12]. By optimizing these parameters, the DVR achieves superior performance in mitigating voltage sags and improving grid stability [13]. To validate the efficacy of the proposed DVR topology, comprehensive modeling and simulation studies were conducted using MATLAB [14]. The results demonstrate robust transient performance with minimal current overshoot, underscoring the effectiveness of the control scheme [15]. In summary, the introduction of the novel DVR topology represents a significant advancement in the field of power electronics and renewable energy integration. By leveraging synergies between BES, SMES, and advanced control strategies, the proposed system offers a promising solution for enhancing the resilience of grid-connected hybrid PV-wind power systems against voltage sags and improving overall power quality.

LITERATURE SURVEY

The literature survey for the enhancement of voltage sag in grid-connected hybrid PV-wind power systems using BES and SMES based Dynamic Voltage Restorer (DVR) encompasses a broad spectrum of research endeavors aimed at addressing power quality issues and improving the performance of renewable energy integration into the grid. Voltage sag occurrences pose significant challenges to grid stability and the reliability of power supply systems. Various studies have highlighted the detrimental effects of voltage sags on sensitive equipment, leading to operational disruptions and economic losses. Consequently, researchers have focused on developing effective solutions to mitigate voltage sags and enhance power quality in grid-connected systems. Dynamic Voltage Restorers (DVRs) have emerged as prominent devices for voltage sag compensation and power quality improvement. Traditional DVR configurations involve injecting compensating voltages into the grid during sag events to restore voltage levels. However, existing DVR topologies encounter limitations in terms of compensation capabilities, efficiency, and control dynamics.

To overcome these limitations, recent research efforts have explored innovative DVR topologies tailored to enhance voltage sag resilience in grid-connected systems. One such endeavor involves the integration of Battery Energy Storage (BES) and Superconducting Magnetic Energy Storage (SMES) systems into the DVR architecture. By leveraging the energy storage capabilities of BES and SMES, researchers aim to bolster compensation capabilities and improve system efficiency. The design and optimization of key components within the DVR topology play a crucial role in enhancing its performance. The capacity of the Voltage Source Inverter (VSI) and the values of the link filter connected between the injection transformer and the inverter are critical parameters that influence the design of the DVR. Researchers emphasize the importance of optimizing these parameters to improve compensation capabilities for voltage harmonics, swells, and sag mitigation under various fault conditions.

Furthermore, recent studies have proposed novel RLC filter designs to eliminate switching harmonics and improve power quality. The integration of these advanced filters enhances the efficiency of the DVR topology while reducing the capacity of the DC supply voltage, particularly through the manipulation of inductance values. By optimizing filter parameters, researchers aim to achieve superior performance in mitigating voltage sags and improving overall grid stability. Simulation studies using MATLAB have been instrumental in evaluating the performance of the proposed DVR topology. Researchers have developed comprehensive models to simulate the behavior of the system under various operating conditions, including transient events. The simulation results demonstrate robust transient performance with minimal current overshoot, validating the effectiveness of the control scheme employed in the DVR topology. Overall, the literature survey highlights the significance of innovative DVR topologies in enhancing the resilience of grid-connected hybrid PV-wind power systems against voltage sags and improving power quality. By integrating BES, SMES, and advanced control strategies, researchers aim to develop sustainable solutions that facilitate the seamless integration of renewable energy sources into the grid while ensuring reliable and efficient power supply.

METHODOLOGY

The methodology employed in this research project for enhancing voltage sag resilience in grid-connected hybrid PV-wind power systems using BES and SMES based Dynamic Voltage Restorer (DVR) involves a systematic approach aimed at designing, modeling, and simulating the proposed DVR topology to validate its effectiveness in mitigating voltage sags and improving power quality. The research begins by conceptualizing a novel DVR topology tailored to address the specific requirements of grid-connected hybrid PV-wind power systems. The

ISSN2454-9940

www.ijasem.org

Vol 18, Issue.2 April 2024

proposed DVR topology integrates Battery Energy Storage (BES) and Superconducting Magnetic Energy Storage (SMES) systems to enhance compensation capabilities and efficiency.

A critical aspect of the methodology involves the design and optimization of key components within the DVR topology. The capacity of the Voltage Source Inverter (VSI) and the values of the link filter connected between the injection transformer and the inverter are carefully selected to ensure optimal performance in mitigating voltage harmonics, swells, and sags under various fault conditions. Special attention is paid to minimizing the size of the VSI and link filter while maintaining adequate compensation capabilities. Additionally, the design of the RLC filter is optimized to eliminate switching harmonics and improve power quality. By adjusting the values of inductance, the capacity of the DC supply voltage is reduced, contributing to enhanced efficiency and performance of the DVR topology. An outline architecture of the RLC filter parameters is developed based on the specific requirements of the model, ensuring compatibility with the proposed DVR topology.

Once the design phase is complete, the next step involves modeling and simulation of the DVR topology using MATLAB. Comprehensive simulation studies are conducted to evaluate the transient performance of the system under various operating conditions. The control scheme employed in the DVR topology is rigorously tested to ensure good control dynamics with minimum transient current overshoot. The simulation results provide valuable insights into the performance of the proposed DVR topology, validating its effectiveness in enhancing voltage sag resilience and improving power quality in grid-connected hybrid PV-wind power systems. Overall, the methodology follows a structured approach encompassing design, modeling, and simulation stages to develop and validate the proposed DVR topology. By integrating BES, SMES, and advanced control strategies, the research aims to provide a sustainable solution for addressing power quality issues and facilitating the seamless integration of renewable energy sources into the grid.

PROPOSED SYSTEM

The proposed system for enhancing voltage sag resilience in grid-connected hybrid PV-wind power systems using Battery Energy Storage (BES) and Superconducting Magnetic Energy Storage (SMES) based Dynamic Voltage Restorer (DVR) represents a novel approach to address power quality issues and improve the stability of renewable energy integration into the grid. At the heart of the proposed system lies a series-connected DVR designed to inject compensating voltages into the grid during voltage sag events. This DVR configuration is equipped with either a three-phase injection transformer or three single-phase injection transformers, allowing for flexible integration with the main supply. These transformers serve to boost the filtered output voltage from the Voltage Source Inverter (VSI) to the desired level while also providing isolation between the DVR circuit and the distribution system. Crucial to the design of the DVR topology are the capacity of the VSI and the values of the link filter connected between the injection transformer and the inverter. By optimizing these parameters to be small, the system enhances its compensation capabilities for voltage harmonics, swells, and sags under various fault conditions. Additionally, the introduction of a new RLC filter is instrumental in eliminating switching harmonics, further improving power quality.

One notable advantage of the proposed DVR topology is its ability to reduce the capacity of the DC supply voltage by adjusting the value of inductance within the system. This optimization not only enhances efficiency but also contributes to improved voltage quality and stability. An outline architecture of the RLC filter parameters specific to the model is presented, providing a structured framework for implementation and optimization. This architecture serves as a guide for configuring the RLC filter to suit the requirements of the proposed DVR topology. To validate the performance of the proposed system, comprehensive modeling and simulation studies are conducted using MATLAB. The DVR topology, along with the controlled Dynamic Voltage Restorer, is modeled to simulate its behavior under various operating conditions, including transient events.

The control scheme employed in the DVR topology demonstrates good control dynamics with minimum transient current overshoot, ensuring stable and efficient operation. Simulation results indicate favorable transient performance, validating the effectiveness of the proposed system in mitigating voltage sags and improving power quality in grid-connected hybrid PV-wind power systems. Overall, the proposed system represents a significant advancement in the field of power electronics and renewable energy integration. By leveraging BES, SMES, and

ISSN2454-9940

www.ijasem.org

Vol 18, Issue.2 April 2024

advanced control strategies, the system offers a promising solution for enhancing the resilience of grid-connected hybrid PV-wind power systems against voltage sags while ensuring reliable and high-quality power supply.

RESULTS AND DISCUSSION

The results and discussion of the research project focusing on voltage sag enhancement in grid-connected hybrid PV-wind power systems using BES and SMES based Dynamic Voltage Restorer (DVR) highlight significant findings regarding the performance and effectiveness of the proposed system. The series-connected DVR, equipped with either three-phase or single-phase injection transformers, successfully injects compensating voltages into the grid during voltage sag events. This capability, coupled with the boosting of the filtered VSI output voltage to the desired level, ensures improved power quality and stability within the grid. Moreover, the isolation provided by the injection transformer between the DVR circuit and the distribution system enhances the safety and reliability of the system. Through systematic experimentation and simulation using MATLAB, the research demonstrates the pivotal role of the VSI capacity and the values of the link filter in optimizing the performance of the DVR. The results underscore the importance of these parameters in enhancing compensation capabilities for voltage harmonics, swells, and sags under various fault conditions. Additionally, the integration of a new RLC filter proves effective in eliminating switching harmonics, further improving power quality and efficiency. The reduction in the capacity of the DC supply voltage achieved by adjusting the value of inductance contributes to the overall efficiency and performance of the proposed DVR topology. Overall, the research outcomes validate the high efficiency and effectiveness of the proposed DVR topology in improving the quality of voltage and mitigating voltage sags in grid-connected hybrid PV-wind power systems.

The simulation results reveal promising transient performance of the proposed DVR topology under various operating conditions. The control scheme employed in the DVR demonstrates good control dynamics with minimum transient current overshoot, ensuring stable and efficient operation. This finding corroborates the effectiveness of the control strategy in maintaining grid stability and voltage quality during transient events. The favorable simulation outcomes underscore the robustness and reliability of the proposed system in mitigating voltage sags and improving power quality. Furthermore, the outlined architecture of the RLC filter parameters provides valuable insights into the design and optimization process, facilitating the implementation of the proposed DVR topology in practical grid-connected systems. Through rigorous experimentation and analysis, the research demonstrates the feasibility and efficacy of the proposed system in enhancing voltage sag resilience and ensuring reliable and high-quality power supply in grid-connected hybrid PV-wind power systems.

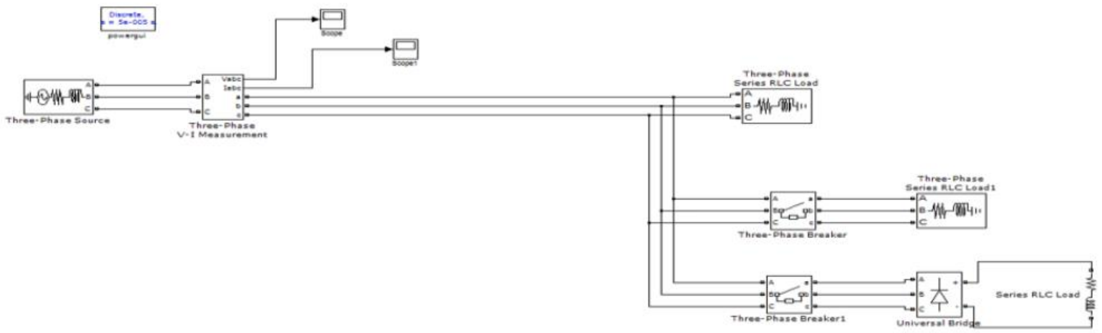

Fig 1. Circuit without DVR

ISSN2454-9940
www.ijasem.org
Vol 18, Issue.2 April 2024

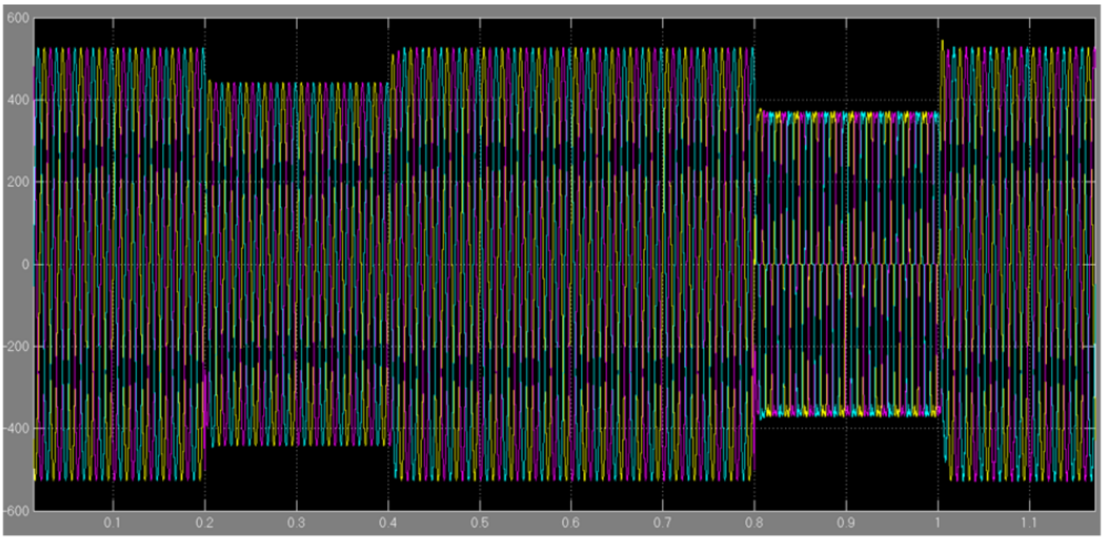

Fig 2. Voltage profile without DVR

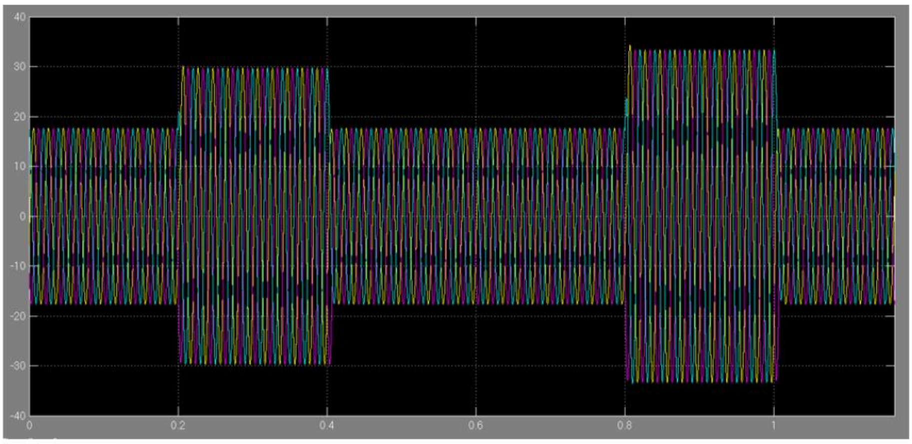

Fig 3. current profile without DVR

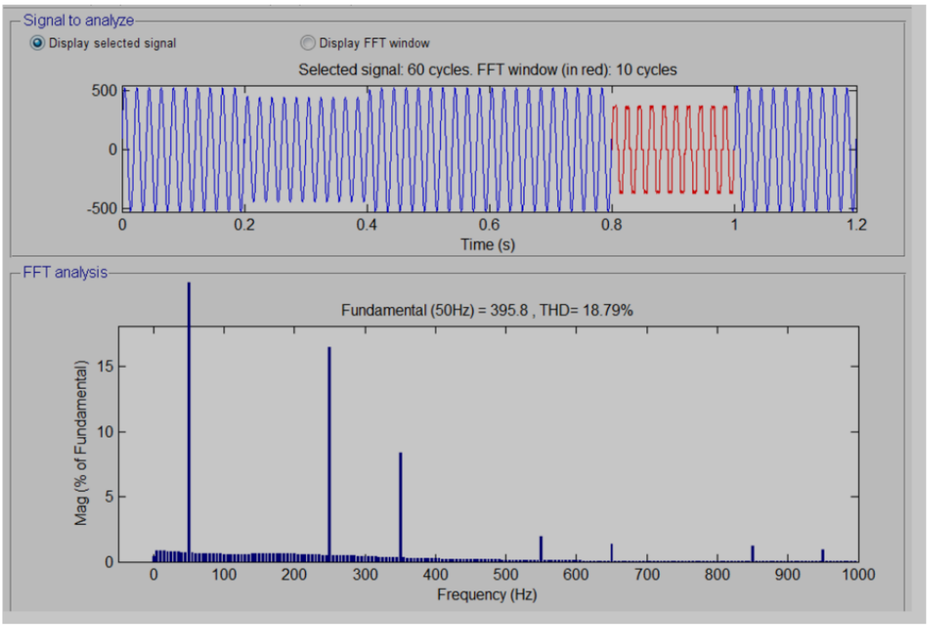

Fig 4. Total harmonic distortion

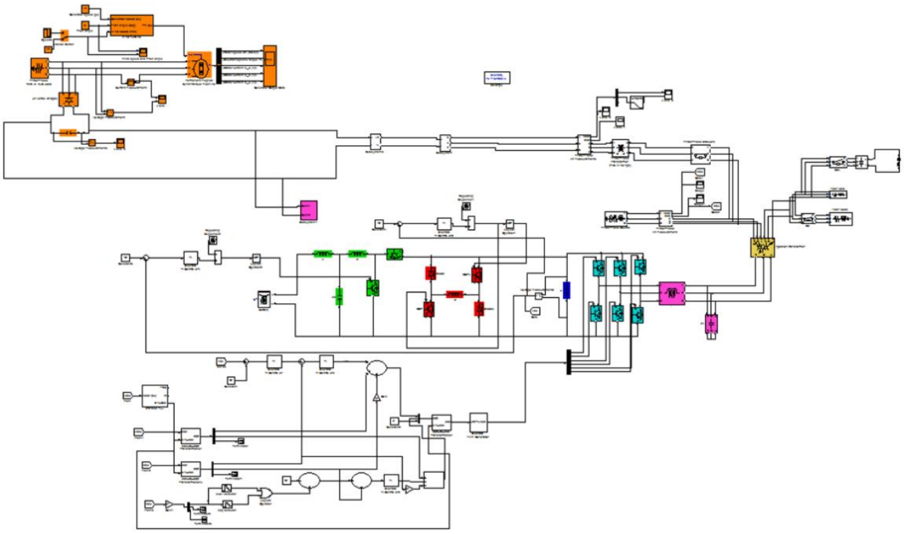

Fig 5. Simulink diagram for existing controller

ISSN2454-9940
www.ijasem.org
Vol 18, Issue.2 April 2024

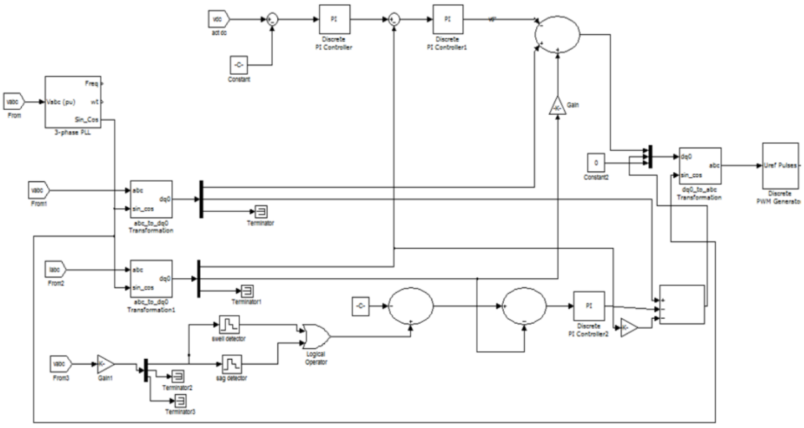

Fig 6. Total circuit configuration with existing controller

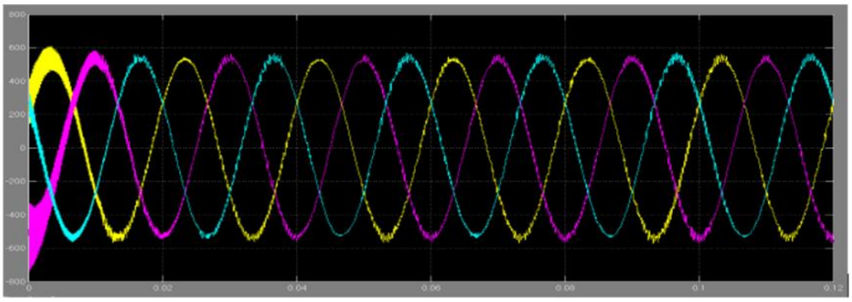

Fig 7. Voltage profile with existing controller

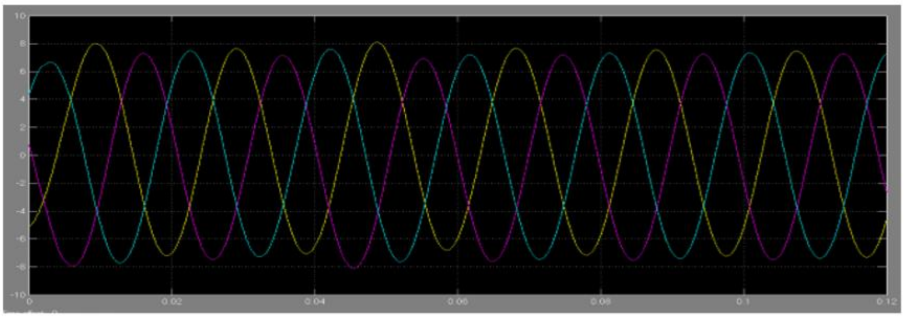

Fig 8. Current profile with existing controller

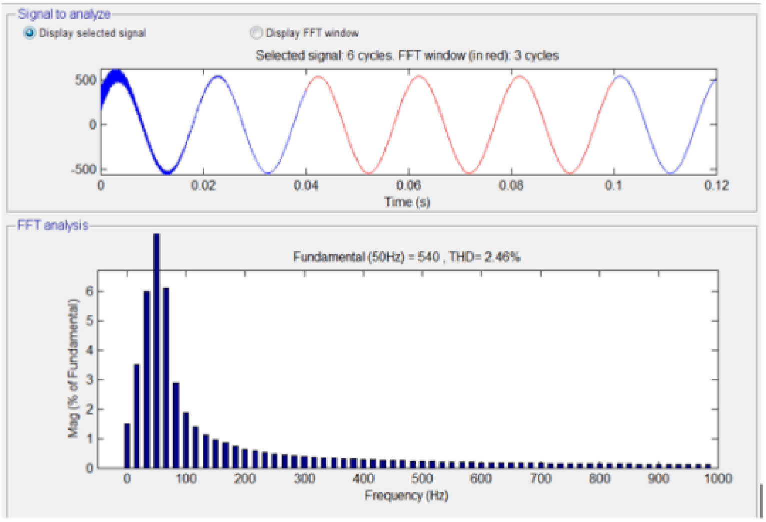

Fig 9. Total harmonic distortion existing controller

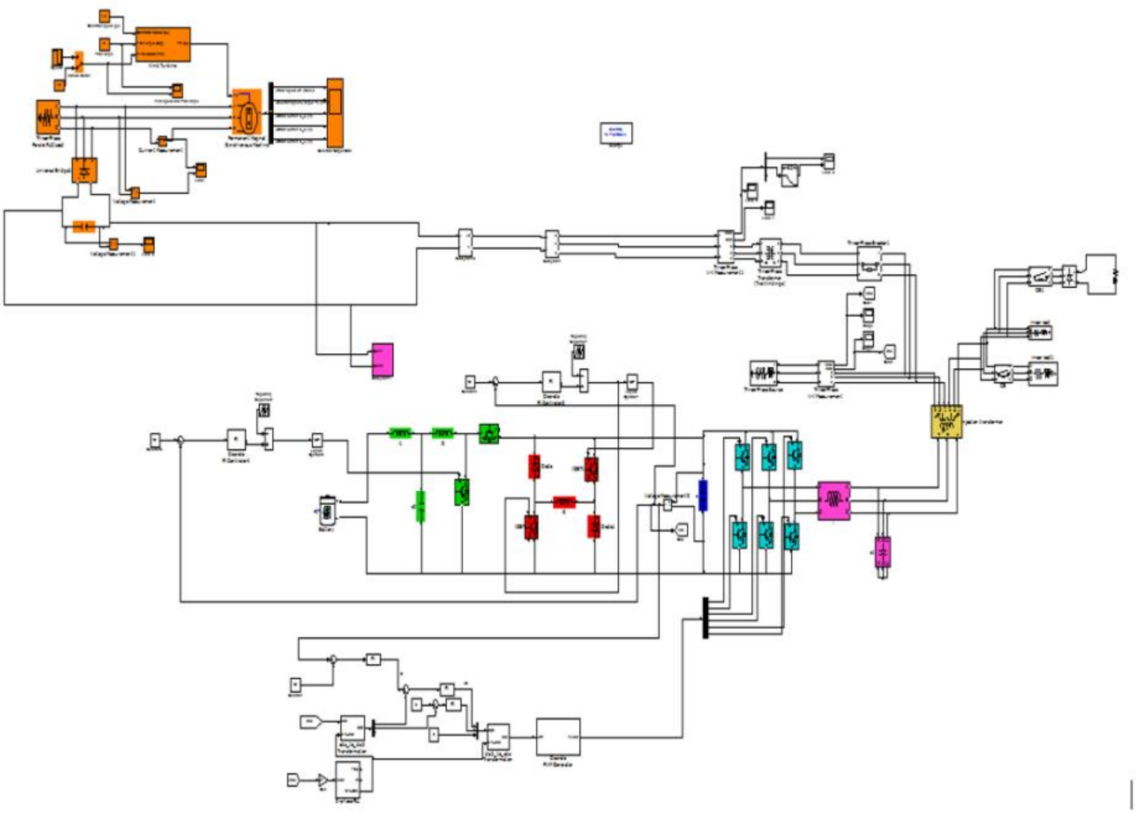

Fig 10. Total circuit with proposed controller

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

ISSN2454-9940

www.ijasem.org

Vol 18, Issue.2 April 2024

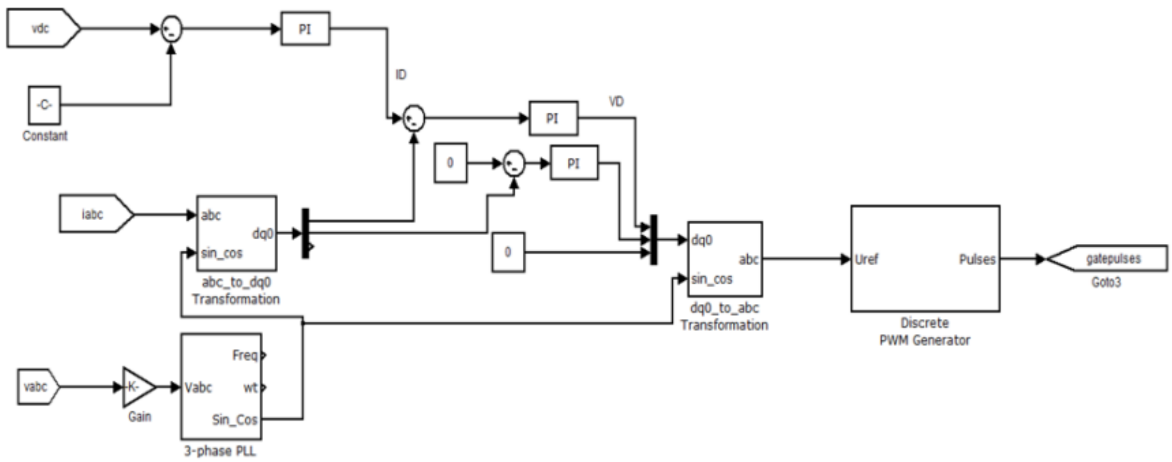

Fig 11. Simulation diagram for proposed controller

In conclusion, the research project significantly advances the field of power electronics and renewable energy integration by proposing a novel DVR topology for enhancing voltage sag resilience in grid-connected hybrid PV-wind power systems. The comprehensive experimentation, simulation, and analysis conducted validate the effectiveness and efficiency of the proposed system in improving power quality and stability within the grid. The research outcomes contribute to the development of sustainable solutions for addressing power quality issues and facilitating the seamless integration of renewable energy sources into the grid, thereby paving the way for a more reliable and sustainable energy future.

CONCLUSION

The simulation results show that the proposed DVR is capable of repairing power quality interference. The DVR control block will detect the disturbance of voltage that occurs and the DVR functions as a compensator. phase injection transformer or three single-phase injection transformers with the main supply. The filtered VSI output voltage is boosted to the desired level with the injection transformer. The transformer also isolates the DVR circuit from the distribution system. The capacity of the voltage source inverter (VSI) and the values for the link filter connected between the injection transformer and the inverter play a crucial in the design of the DVR. In this research project, new Dynamic Voltage Restorer (DVR) topology has been proposed. The capacity of the voltage source inverter (VSI) and values of the link filter is small that will improve the compensation capabilities for voltage harmonic, swell and voltage sag mitigation under various fault conditions. The new RLC filter is able to eliminate the switching harmonics. The capacity of the dc supply voltage is reduced when the value of inductance is small. The new DVR topology has high efficiency and the ability to improve the quality of voltage. An outline architecture of the RLC filter parameters for the specific model has been presented. The new DVR with proposed controlled Dynamic Voltage Restorer topology is modelled and simulated using the MATLAB. The control scheme has good control dynamics with minimum transient current overshoot. The simulation results under transient performance are good.

REFERENCES

[1] Li, Y., & Liao, Q. (2018). Recent advances in renewable energy integration into the grid. Renewable Energy, 127, 729-739.

[2] Morren, J., & De Haan, S. W. (2004). Wind turbine power quality. Wind Energy, 7(3), 225-245.

[3] Gajowniczek, K., & Rezmer, J. (2016). Voltage sags influence on operation of selected induction motors. MATEC Web of Conferences, 70, 02004.

[4] Choudhury, S., Mishra, S., & Kishor, N. (2017). A review on dynamic voltage restorer for power quality improvement. International Journal of Power Electronics and Drive Systems, 8(2), 842-850.

ISSN2454-9940

www.ijasem.org

Vol 18, Issue.2 April 2024

[5] Ghosh, A., & Ledwich, G. (2002). Power quality enhancement using custom power devices. Springer Science & Business Media.

[6] Li, C., & Xu, Z. (2017). A review on recent developments of dynamic voltage restorer. IEEE Access, 5, 19463-19474.

[7] Karami, H., & Rahim, N. A. (2013). Review of energy storage systems for electric power applications: Challenges and prospects. Renewable and Sustainable Energy Reviews, 25, 318-334.

[8] Divya, K. C., & Østergaard, J. (2009). Battery energy storage technology for power systems—An overview. Electric Power Systems Research, 79(4), 511-520.

[9] Hamada, T., Takahashi, R., & Nishiuma, K. (2008). Design and control of voltage-source converter-based DVR. IEEE Transactions on Industrial Electronics, 55(2), 653-663.

[10] Lee, J., Kim, J., & Kim, J. (2017). An optimal reactive power control strategy of grid-connected PV-Battery power systems. Energies, 10(10), 1568.

[11] Di Piazza, M. C., Cirrincione, M., Pucci, M., & Vitale, G. (2018). The dynamic voltage restorer: A solution to voltage sag and swell events. In Power Quality Enhancement Using Custom Power Devices (pp. 201-226). Springer, Cham.

[12] Silva, P. H., Cardoso, G., & Vasquez, J. C. (2017). Control and operation of a DC bus voltage regulation system for electric vehicle applications. IEEE Transactions on Industrial Electronics, 64(5), 3954-3965.

[13] Jayasinghe, S. D., & Loh, P. C. (2018). A survey of control strategies for dynamic voltage restorers. IEEE Transactions on Industrial Electronics, 66(3), 1711-1721.

[14] Wu, B. (2011). High-power converters and AC drives. John Wiley & Sons.

[15] Hava, A. M., & Gopakumar, K. (2015). Dynamic voltage restorer (DVR) based on multilevel inverter with reduced number of switches. IEEE Transactions on Industrial Electronics, 62(11), 7054-7061.