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Renewable Energy Control for Three-Phase Hybrid Microgrid System

Mrunal B. Zine
Department of Electrical Engineering,Shri Sant Gajanan Maharaj College of Engineering
Shegaon, India
sunnyzine7@gmail.com

Pratik A. Asolkar
Department of Electrical Engineering,Shri Sant Gajanan Maharaj College of Engineering
Shegaon, India
pratikasolkar000@gmail.com

Yash D. Ingale
Department of Electrical Engineering,Shri Sant Gajanan Maharaj College of Engineering
Shegaon, India
yingale854@gmail.com

Pratham S. Rathod
Department of Electrical Engineering,Shri Sant Gajanan Maharaj College of Engineering
Shegaon, India
prathamrathod175@gmail.com

Sopan P. Wankhade
Department of Electrical Engineering,Shri Sant Gajanan Maharaj College of Engineering
Shegaon, India
sopanwankhade2002@gmail.com

Abstract— This project focuses on the development of a sophisticated renewable energy-based modeling and control system for a three-phase hybrid microgrid using MATLAB-Simulink. Incorporating elements such as PV and wind power generation, IGBT or MOSFET inverters, and an RLC load with predetermined values, the system aims to demonstrate efficient power generation, distribution, and management within the microgrid. Moreover, it includes a comprehensive monitoring system for voltage, current, and power parameters. The graphical display provides a user-friendly interface to visualize and analyze the system's output, facilitating a deeper understanding of the microgrid's performance and enabling potential enhancements in renewable energy integration and grid stability.

The project culminates in a user-friendly graphical display interface, allowing stakeholders to visualize and comprehend the intricate dynamics of the microgrid. This interface provides a detailed output presentation, enabling stakeholders to interpret and analyze the data effectively. The graphical display serves as an invaluable tool for researchers, engineers, and decision-makers, empowering them to optimize the microgrid's performance, enhance renewable energy integration, and ensure grid stability.

Keywords— Hybrid Microgrid, Solar Photovoltaic, Power Generation System, Hybrid System.

I. INTRODUCTION

A. BACKGROUND

The urgent need to slow down climate change and lessen reliance on fossil fuels has caused a dramatic shift in the world's energy landscape in recent years. A move toward renewable energy sources including solar, wind, and hydroelectric power characterizes this transition. Microgrids are a viable approach to use renewable energy sources. They can help improve energy resiliency, encourage sustainability, and facilitate localized power generation and distribution.

A microgrid is a localized group of electricity sources and loads that run independently as an islanded system or linked to the conventional centralized grid. It incorporates a range of distributed energy resources (DERs), such as energy storage systems and renewable energy sources (ESS), and conventional generators, along with advanced control and management technologies. This configuration offers several advantages over conventional centralized power systems, including improved reliability, enhanced efficiency, and increased utilization of renewable energy.

In the context of microgrid systems, the hybrid approach, which combines multiple sources of energy, has gained considerable attention due to its ability to leverage the complementary characteristics of different energy sources. By integrating renewable energy sources such as solar and wind with conventional generators and energy storage systems, hybrid microgrids can optimize energy production, enhance system stability, and reduce dependency on fossil fuels.

This project focuses on the implementation of renewable energy-based modeling and control techniques for a three-phase hybrid microgrid system. The three-phase configuration is commonly utilized in industrial and commercial applications, offering advantages in terms of power quality and compatibility with three-phase loads. The hybrid nature of the microgrid enables the efficient utilization of renewable energy sources while ensuring reliable and continuous power supply to consumers.

B. PROBLEM STATEMENT

The burgeoning demand for renewable energy integration within microgrid systems has underscored the critical need for efficient modeling, control, and monitoring frameworks. The challenge lies in effectively harnessing the intermittent nature of renewable sources like solar and wind power while ensuring stable and reliable power distribution. Current systems often lack robust control mechanisms to manage the variability of these sources, leading to inefficiencies, grid instability, and underutilization of renewable potential. To address these limitations, our proposed system seeks to develop an intricate yet adaptable framework integrating PV and wind power generation, precise inverter control, and comprehensive monitoring, aiming to optimize renewable energy utilization and enhance microgrid stability.

II. LITERATURE REVIEW

1. Vinay Kumar Dewangan et al. This research examines and simulates a wind-photovoltaic hybrid power generation system model. a microgrid that is run as a single controllable system made up of a collection of dispersed generators and loads. The microgrid can operate alongside the main power grid or independently of it as an integrated energy handling system. Several reverse conversions in a separate DC or AC grid are scarce in this idea, which also brings instantaneous links to fluctuating renewable DC and AC sources and loads to power systems. The microgrid can be customized to satisfy each user's unique needs, including maximizing efficiency by utilizing waste heat, minimizing feeder losses, supporting local voltage profiles, and improving local dependability. improvement of voltage sag and maintain continuous power supply.

2. Kirmani, Akhtar, Iram, and Sheeraz, et al. In order to integrate solar and wind energy into the grid, the author suggested a system that combines an inverter circuit with a boost converter. The suggested work applies model predictive control to a three-phase inverter and makes use of a model to anticipate future system voltage values for a given voltage sequence. Moreover, the boost converter's output voltage can be modified via the cosine firing angle arrangement. The utility grid can continually supply or absorb high-quality power thanks to the three-phase inverter's use as a harmonic reduction device.

3. Ayman Al-Quraan et al. The author of this research presents a stand-alone micro-grid system that is constructed and managed using a photovoltaic (PV) and wind energy conversion system (WECS)-based permanent magnet synchronous generator (PMSG). To regulate and extract the maximum power available for the PV system, a boost converter is equipped with a fuzzy logic-based Maximum Power Point Tracking (MPPT) system. In every situation, the control system is made to provide the necessary energy to a particular load.

4. Hamid Reza Baghaee et al. This work proposes a novel decentralized robust technique to enhance hybrid AC/DC microgrid performance for nonlinear and unbalanced loads, while also improving small and large-signal stability and power-sharing. In addition to the sliding mode controller for DC/DC converters, two additional controllers are designed for positive sequence power control and negative sequence current control based on Lyapunov function theory and sliding mode control, respectively, in order to improve power sharing, regulate active and reactive powers injected by distributed energy resources, and control harmonic and negative-sequence current in the presence of nonlinear and unbalanced loads.

5. Ibrahim Alhamrouni et al. In addition to describing an effective microgrid control method, the research models hybrid AC microgrids. The performance of hybrid AC microgrid systems is examined in the islanded mode in the current work. Microgrid development makes use of fuel cell stacks and photovoltaic systems. It also covers the goals of microgrid control, the most frequent issues that arise, and how to fix them. The output voltage can be regulated by the used control method to a desirable and consistent value. MATLAB/SIMULINK is used to model the hybrid AC microgrid's control techniques.

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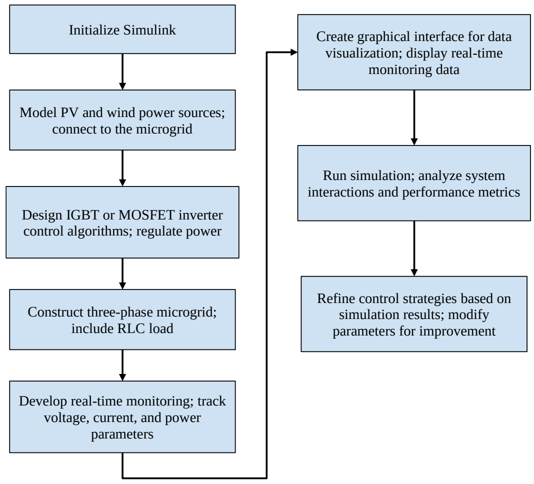
III. METHODOLOGY

The proposed system orchestrates a cohesive interplay of diverse components to ensure efficient functioning of the hybrid microgrid. It begins with the integration of photovoltaic (PV) and wind power generation systems, harnessing solar and wind energy. These renewable sources feed into IGBT or MOSFET inverters, enabling precise control of power output. The controlled power is then channeled into a three-phase system, accommodating an RLC load to simulate real-world consumption. A pivotal aspect lies in the implementation of a comprehensive monitoring system that continuously tracks voltage, current, and power parameters within the microgrid. This data is fed into a user-friendly graphical interface, offering stakeholders an intuitive platform to visualize and analyze the microgrid's performance. The system's core lies in its ability to manage and optimize power flow, ensuring stability while maximizing the integration of renewable energy sources.

IV. FLOW CHART



V. CIRCUIT DIAGRAM

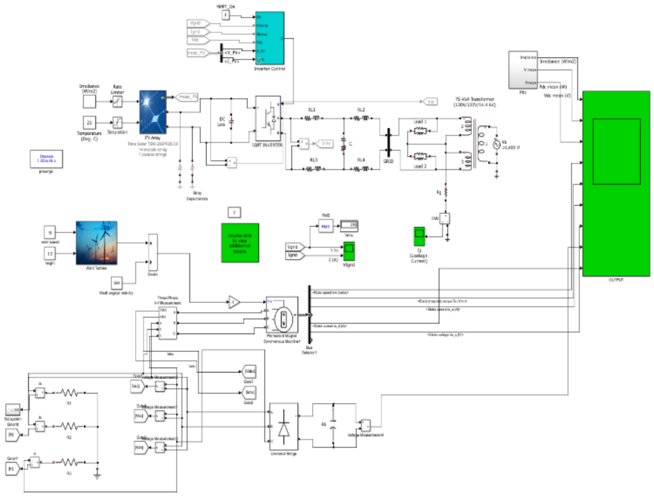


Fig (1)

CONCLUSION

The developed system stands as a testament to the potential of renewable energy integration within microgrid frameworks. Through the seamless orchestration of photovoltaic and wind power sources, precise control mechanisms via IGBT or MOSFET inverters, and a comprehensive monitoring system, this project underscores the feasibility of sustainable energy solutions. The system's ability to optimize power flow, ensure grid stability, and maximize renewable energy utilization heralds a promising stride towards a more resilient and eco-friendly energy landscape. With its user-friendly interface enabling insightful analysis, this endeavor paves the way for future advancements in microgrid technology, offering a blueprint for efficient, renewable-centric power systems. In addition, the adaptability of this system fosters scalability and resilience, catering to evolving energy demands. Its capacity to balance intermittent renewable sources and provide stable power distribution underscores its significance in mitigating dependency on conventional grids. As renewable energy continues to gain prominence, this project exemplifies a pivotal step towards sustainable energy models, promoting environmental stewardship and energy independence on a broader scale.

RESULT

The below graph shows the Output gained from the circuit of inter connected Three-Phase Hybrid Microgrid System. In which we get to see the output of the solar and wind power generating system. The 1st ,2nd & 3rd graph shows the waveform of the solar system outputs, whereas the other graphs show the output of the wind power system.

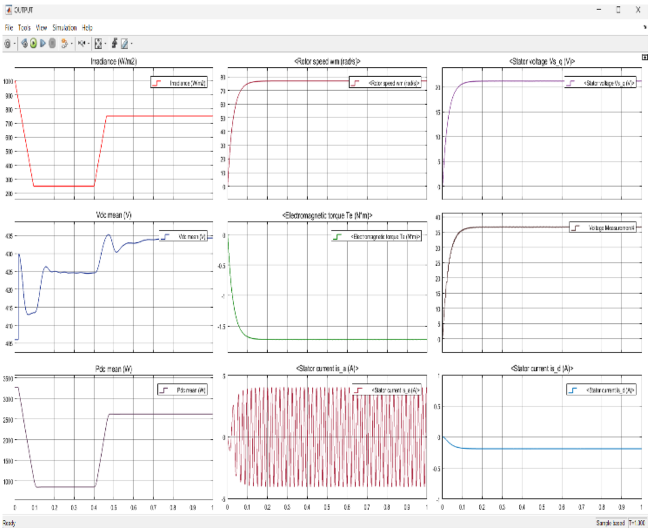


Fig (A)

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