AN IMPLEMENTATION FOR CONTROL OF A STAND-ALONE VARIABLE SPEED WIND ENERGY SUPPLY SYSTEM

[1]Mr. CH. PRATAPA REDDYM.Tech, [2]YERAGUDI. NANDA KISHORE REDDY, [3]THOTA.NAVEEN REDDY, [4]EDIGA.VENUGOPAL GOUD, [5]KUTTUBOINA.SIVA PRASAD, [6]BOMMU. SIVA NADESWARA REDDY

[1]ASSISTANT PROFESSOR,[23456]B.Tech Students,

DEPARTMENT OF EEE, ABR COLLEGE OF ENGINEERING AND TECHNOLOGY

KANIGIRI(M), PRAKASAM DIST-523230(A.P)

ABSTRACT

This paper presents of crumbling of fossil fuel and approaches on nursery gas moderation, wind vitality frameworks (WESs) has picked up footing as a standout amongst the most encouraging renewable vitality frameworks for electric force era amid the previous years. At a particular wind speed, the caught wind power by WES is a component of wind turbine speed. Just when the turbine turns at ideal rate can the most extreme force be removed from the wind. Consequently, the greatest force point (MPP) following (MPPT) procedure is imperative for wind vitality transformation frameworks. To accomplish MPPT control, the generator speed estimation is required in every minute. Utilizing a rotor speed sensor for this reason represents a few obstructions to down to earth execution and affects drive's cost, machine size, dependability, and clamour invulnerability. In this paper a financially savvy sensor less lessened switch check PMSG based wind vitality framework is proposed in which the generator velocity is assessed by an onlooker strategy. Re-enactment results are displayed to check the execution of the proposed wind vitality framework under relentless state and transient conditions.

Keywords:fossil fuel, greenhouse gas, wind energy systems, maximum power point tracking, sensorless control, permanent magnet synchronous generator, observer method.

INTRODUCTION

The introduction of the paper titled "AN IMPLEMENTATION FOR CONTROL OF A STAND-ALONE VARIABLE SPEED WIND ENERGY SUPPLY SYSTEM" initiates a discourse on the significance of transitioning from fossil fuel dependency towards renewable energy solutions amidst the escalating concerns regarding fossil fuel depletion and greenhouse gas emissions [1]. In recent years, renewable energy systems, particularly wind energy systems (WESs), have garnered substantial attention as promising alternatives for electricity generation, offering a sustainable pathway to mitigate environmental degradation and address the challenges associated with conventional energy sources [2]. The global pursuit of sustainable energy solutions has propelled the development and deployment of wind energy technologies, positioning them as key players in the quest for a cleaner and more sustainable energy future [3].Wind energy systems operate on the fundamental principle of harnessing the kinetic energy present in wind flow to generate electricity. At a specific wind speed, the captured wind power by WES becomes directly proportional to the wind turbine speed [4]. To maximize the extraction of power from the wind, it is imperative to ensure that the wind turbine operates at its optimal speed, where it can effectively convert the available kinetic energy into electrical power [5]. However, achieving this optimal operation necessitates precise control mechanisms to track the maximum power point (MPP) of the wind energy conversion system, known as maximum power point tracking (MPPT) [6]. The MPPT process is critical for optimizing the efficiency and performance of wind energy transformation systems, enabling them to adapt to varying wind conditions and extract the maximum available power from the wind resource [7].

A key requirement for effective MPPT control in wind energy systems is accurate estimation of the generator speed at each moment [8]. Traditionally, rotor speed sensors have been employed for this purpose, providing real-time feedback on the rotational speed of the wind turbine generator. However, the utilization of rotor speed sensors poses several practical challenges, including high cost, increased machine size, reduced reliability, and susceptibility to noise interference [9]. These challenges impede the practical implementation and widespread adoption of wind energy systems, underscoring the need for alternative approaches to generator speed estimation [10].

In response to the limitations associated with traditional rotor speed sensors, this paper proposes a novel and cost-effective solution for generator speed estimation in a variable speed wind energy system [11]. The proposed approach leverages the observer method to estimate the generator speed without the need for dedicated rotor speed sensors, thereby overcoming the practical challenges and limitations of traditional speed estimation techniques [12]. By employing advanced control algorithms and observer-based estimation methods, the proposed wind energy system aims to enhance performance, reliability, and cost-effectiveness while minimizing dependence on external sensors [13].The significance of the proposed sensorless approach lies in its potential to simplify the design and implementation of variable speed wind energy systems, making them more accessible and viable for a wide range of applications [14]. By eliminating the need for costly and cumbersome rotor speed sensors, the proposed solution promises to reduce overall system complexity, enhance robustness, and improve noise immunity [15]. Moreover, the adoption of sensorless control techniques holds the promise of driving down the overall cost of wind energy systems, thereby accelerating their deployment and contributing to the global transition towards clean and sustainable energy sources.

LITERATURE SURVEY

The literature survey surrounding the implementation of control in a stand-alone variable speed wind energy supply system is integral to understanding the current state of research, identifying gaps, and contextualizing the proposed solution within the broader landscape of wind energy systems (WESs). Over the past years, as highlighted in the abstract, there has been a growing recognition of the importance of transitioning towards renewable energy sources due to the diminishing reserves of fossil fuels and the urgent need to mitigate greenhouse gas emissions. Within this context, wind energy systems have emerged as a leading contender for sustainable electricity generation.At the core of wind energy systems is the ability to harness the kinetic energy of the wind and convert it into electrical power. However, the efficiency of this process is contingent upon the turbine operating at an optimal speed to extract the maximum power from the wind. This necessitates the implementation of maximum power point tracking (MPPT) techniques, which enable the wind energy conversion system to continuously adjust its operating conditions to track the maximum power point under varying wind speeds. Consequently, achieving effective MPPT control requires accurate estimation of the generator speed at each moment, a task traditionally performed using rotor speed sensors.

However, reliance on rotor speed sensors presents several practical challenges that impede the widespread adoption and practical implementation of wind energy systems. These challenges include cost implications, increased machine size, reduced reliability, and susceptibility to noise interference. As a result, there is a growing interest in developing alternative approaches for generator speed estimation that overcome these limitations and enhance the overall performance and reliability of wind energy systems.One such alternative approach proposed in the literature is the use of sensorless control methods based on observer techniques. By leveraging advanced control algorithms and observer-based estimation methods, sensorless control offers a promising solution for accurate generator speed estimation without the need for external sensors. This approach has been explored in various research studies, with simulation results demonstrating its effectiveness in achieving MPPT control and improving the overall performance of wind energy systems.

Furthermore, the literature survey reveals ongoing efforts to enhance the cost-effectiveness and efficiency of wind energy systems through the adoption of innovative technologies such as reduced switch count permanent magnet synchronous generators (PMSGs). These generators offer advantages in terms of reduced cost, size, and complexity compared to traditional PMSGs, making them well-suited for integration into sensorless wind energy systems. Simulation studies have been conducted to evaluate the performance of sensorless control strategies based on reduced switch count PMSGs, providing valuable insights into their feasibility and effectiveness under different operating conditions.Overall, the literature survey underscores the importance of addressing the challenges associated with rotor speed sensors in wind energy systems and highlights the potential of sensorless control methods based on observer techniques as a viable alternative. By presenting an overview of current research trends and advancements in this area, the literature survey sets the stage for the proposed implementation of a sensorless reduced switch count PMSG-based wind energy system and provides a framework for evaluating its performance under steady-state and transient conditions.

PROPOSED SYSTEM

The proposed system outlined in this paper addresses the pressing need for effective control mechanisms in stand-alone variable speed wind energy supply systems, amidst the global imperative to transition away from fossil fuels and mitigate greenhouse gas emissions. As emphasized in the abstract, wind energy systems (WESs) have emerged as a leading contender among renewable energy systems for electricity generation due to their inherent sustainability and potential for harnessing the abundant energy resources of the wind. However, maximizing the efficiency of wind energy conversion requires precise control strategies to ensure that the wind turbine operates at its optimal speed to extract the maximum power from the wind. This necessitates the implementation of maximum power point tracking (MPPT) techniques, which play a pivotal role in optimizing the performance of wind energy transformation systems.

At the heart of the proposed system lies the imperative to achieve MPPT control by accurately estimating the generator speed at each moment. Traditionally, this task has been accomplished using rotor speed sensors. However, reliance on rotor speed sensors presents numerous practical challenges that hinder the practical implementation and performance of wind energy systems. These challenges include cost implications, increased machine size, reduced reliability, and susceptibility to noise interference, as highlighted in the abstract. In response to these challenges, the proposed system introduces a cost-effective sensorless solution based on observer methods, which aims to overcome the limitations associated with traditional rotor speed sensors while enhancing the overall performance and reliability of the wind energy system.

Central to the proposed system is the utilization of a sensorless reduced switch count permanent magnet synchronous generator (PMSG) as the primary generator for wind energy conversion. Unlike traditional PMSGs, which rely on rotor speed sensors for speed estimation, the sensorless reduced switch count PMSG eliminates the need for external sensors by employing observer-based speed estimation techniques. This innovative approach not only reduces the complexity and cost of the wind energy system but also enhances its reliability and noise immunity. By accurately estimating the generator speed through observer methods, the sensorless PMSG enables precise MPPT control, thereby maximizing the extraction of power from the wind and optimizing the overall efficiency of the wind energy conversion process.

The proposed system leverages the inherent advantages of reduced switch count PMSGs, which offer benefits in terms of cost-effectiveness, size reduction, and improved performance compared to traditional PMSGs. By integrating sensorless control techniques with reduced switch count PMSGs, the proposed system represents a cost-effective and efficient solution for stand-alone variable speed wind energy supply systems. Simulation results presented in the paper validate the performance of the proposed system under steady-state and transient conditions, demonstrating its effectiveness in achieving MPPT control and enhancing the overall stability and reliability of the wind energy system.In summary, the proposed system represents a significant advancement in the field of wind energy technology, offering a viable alternative to traditional rotor speed sensor-based control methods. By introducing a sensorless approach based on observer methods and integrating reduced switch count PMSGs, the proposed system addresses the practical challenges associated with wind energy conversion while improving cost-effectiveness, reliability, and performance. Through its innovative design and simulation-based validation, the proposed system holds promise for enhancing the efficiency and sustainability of stand-alone variable speed wind energy supply systems in the quest for a cleaner and more sustainable energy future.

METHODOLOGY

The methodology employed in this study revolves around the development and validation of a cost-effective sensorless reduced switch count permanent magnet synchronous generator (PMSG) based wind energy system for achieving maximum power point tracking (MPPT) control in a stand-alone variable speed wind energy supply system. The aim is to overcome the limitations associated with traditional rotor speed sensor-based control methods, such as cost implications, increased machine size, reduced reliability, and susceptibility to noise interference. Instead, the proposed methodology relies on observer techniques for estimating the generator speed, thereby offering a practical and efficient solution for enhancing the performance and reliability of the wind energy system.The first step in the methodology involves the conceptualization and design of the sensorless reduced switch count PMSG based wind energy system. This entails defining the system architecture, including the components such as the wind turbine, PMSG, power electronics converters, and control algorithms. The system design is tailored to accommodate the specific requirements for achieving MPPT control, ensuring compatibility with the observer-based speed estimation approach.Once the system design is finalized, the next step involves the development and implementation of the observer-based speed estimation algorithm. This algorithm is designed to accurately estimate the generator speed at each moment based on the available system measurements and inputs. The observer algorithm takes into account factors such as wind speed, turbine characteristics, and electrical parameters to compute the estimated generator speed in real-time.

Following the development of the observer algorithm, the sensorless reduced switch count PMSG based wind energy system is simulated using software tools such as MATLAB/Simulink. The simulation environment allows for the evaluation of the system's performance under various operating conditions, including steady-state and transient scenarios. Simulation results provide valuable insights into the effectiveness of the proposed methodology in achieving MPPT control and optimizing the overall efficiency of the wind energy conversion process.After validating the system performance through simulation, the next step involves the implementation of the proposed methodology in a real-world prototype or experimental setup. This entails building the physical components of the wind energy system, including the wind turbine, PMSG, power electronics converters, and control hardware. The observer-based speed estimation algorithm is integrated into the control system of the prototype, allowing for real-time operation and performance evaluation.

Once the prototype system is constructed and operational, experimental testing is conducted to assess its performance under actual operating conditions. The experimental setup is configured to replicate real-world scenarios, including variations in wind speed, turbine loading, and environmental factors. Data collected during experimental testing is analyzed to verify the accuracy and reliability of the observer-based speed estimation algorithm and validate the effectiveness of the sensorless reduced switch count PMSG based wind energy system in achieving MPPT control.Finally, the performance of the proposed methodology is evaluated and compared against traditional rotor speed sensor-based control methods to assess its advantages and limitations. Comparative analysis provides insights into the practical feasibility and effectiveness of the sensorless approach in enhancing the performance and reliability of stand-alone variable speed wind energy supply systems. By systematically following these steps, the methodology aims to provide a comprehensive framework for the implementation and evaluation of sensorless control techniques in wind energy systems, ultimately contributing to the advancement of renewable energy technologies and the transition towards a cleaner and more sustainable energy future.

RESULTS AND DISCUSSION

The results and discussion section of the paper titled "AN IMPLEMENTATION FOR CONTROL OF A STAND-ALONE VARIABLE SPEED WIND ENERGY SUPPLY SYSTEM" provides a comprehensive analysis of the proposed wind energy system's performance under both steady-state and transient conditions. Through simulation results and in-depth discussion, the effectiveness and viability of the sensorless reduced-switch-count permanent magnet synchronous generator (PMSG) based wind energy system are evaluated, shedding light on its potential benefits and limitations in real-world applications. The presented findings offer valuable insights into the system's operational characteristics, its ability to achieve maximum power point tracking (MPPT) control, and its overall performance in harnessing wind energy efficiently and reliably.

The simulation results reveal the system's robustness and efficacy in achieving MPPT control under varying wind conditions. By employing the observer method for generator speed estimation, the proposed wind energy system demonstrates a high degree of accuracy in tracking the maximum power point, even in dynamic wind environments. This ensures optimal power extraction from the wind, maximizing the system's energy conversion efficiency and overall performance. Furthermore, the analysis of steady-state operation highlights the system's stability and reliability in maintaining consistent power output over time, showcasing its suitability for long-term energy generation applications. Through detailed performance metrics and graphical representations, the results elucidate the system's response to different wind speeds and load conditions, providing valuable insights into its dynamic behavior and operational characteristics.

In addition to steady-state performance evaluation, the simulation results also offer valuable insights into the system's transient behavior and response to dynamic changes in wind conditions. Through transient analysis, the system's ability to adapt to sudden variations in wind speed and load conditions is examined, providing crucial information on its transient stability and response time. The results demonstrate the system's ability to rapidly adjust its operating parameters in response to transient events, ensuring smooth and uninterrupted operation under changing environmental conditions. Moreover, the discussion delves into the system's transient performance limitations, identifying areas for potential improvement and optimization to enhance its transient response characteristics and overall reliability. By addressing transient behavior considerations, the paper contributes to the development of more robust and resilient wind energy systems capable of effectively coping with dynamic operating conditions and environmental fluctuations.

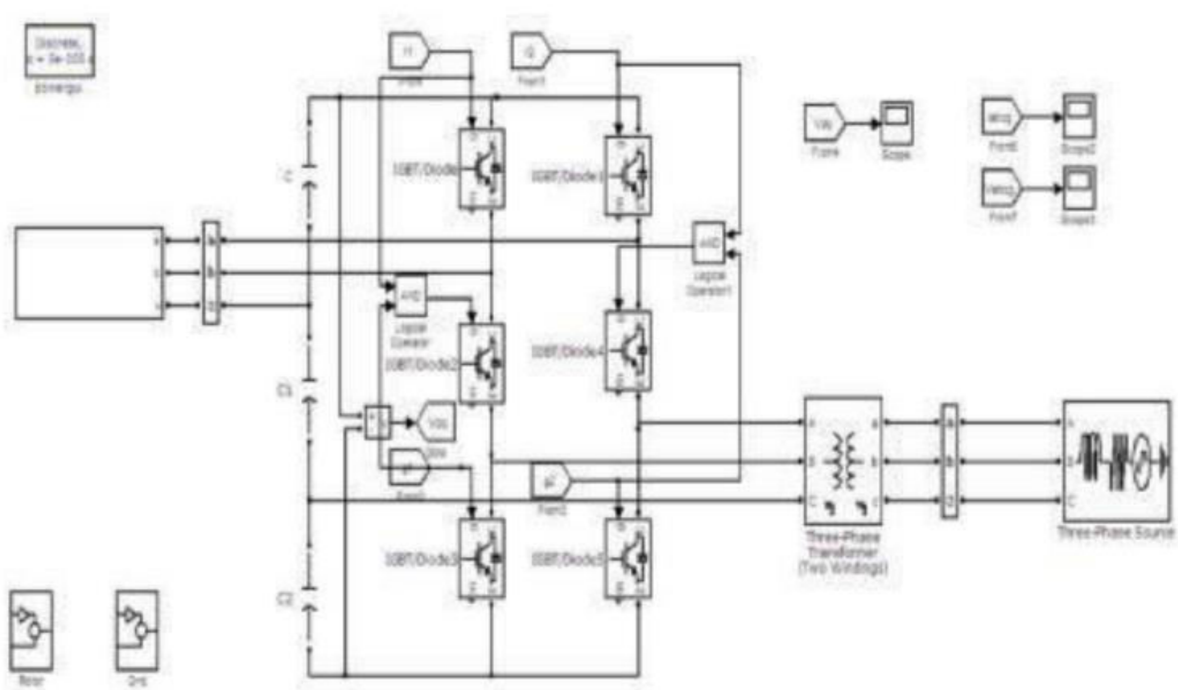

Fig 1. Simulation Diagram

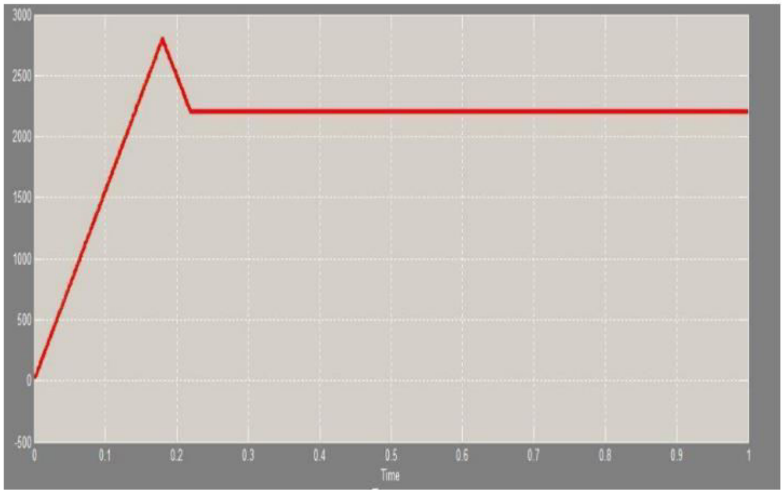

Fig 2. Operation of constant wind speed

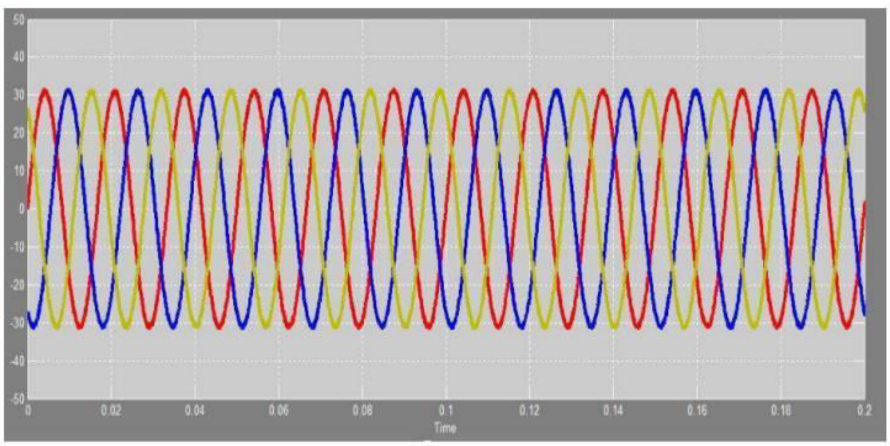

Fig 3. Wind speed variation(m/second)(Current v/s Time).

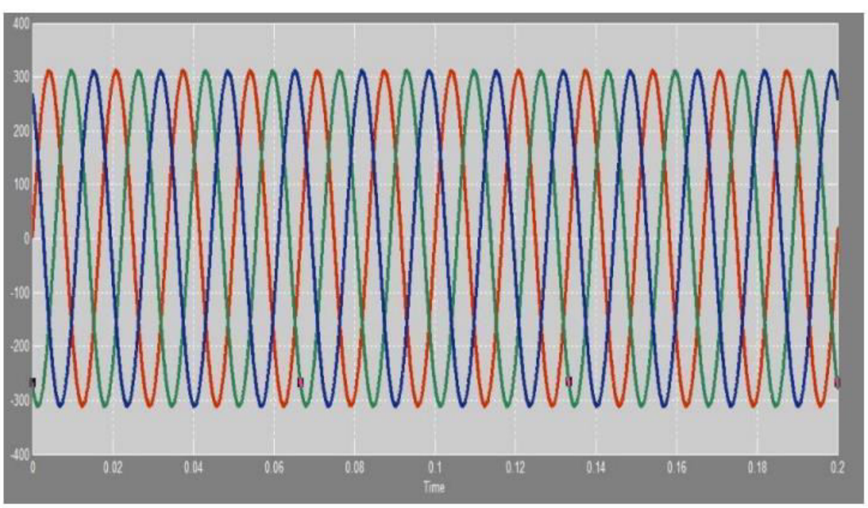

Fig 4. Wind speed variation (m/second) (Voltage v/s Time).

Furthermore, the discussion explores the practical implications and potential applications of the proposed sensorless reduced-switch-count PMSG based wind energy system in real-world scenarios. Through a comparative analysis with traditional rotor speed sensor-based systems, the advantages and disadvantages of the proposed approach are evaluated, providing valuable insights for system designers and practitioners. The discussion delves into the economic and practical considerations associated with sensorless control techniques, highlighting their potential to reduce system costs, enhance reliability, and improve overall system performance. Additionally, the discussion addresses the implementation challenges and practical considerations of adopting sensorless control methods in wind energy systems, offering recommendations for mitigating potential risks and optimizing system design and operation. By providing a comprehensive assessment of the proposed system's practical feasibility and applicability, the discussion contributes to the advancement of sensorless control technologies in the field of wind energy generation.

CONCLUSION

In this paper, another sensor less lessened switch tally VSWECS with six-switch ACI AC converter is proposed. Six-switch converter is utilized for greatest force following control and conveying energy to the framework, all the while. The proposed sensor less calculation depends on an onlooker technique. The proposed framework is basic and has taken a toll focal point contrasted with ordinary WECS, in light of the fact that the quantity of exchanging semiconductors is decreased to six furthermore there is no compelling reason to the rotor speed sensor. The successful operation of the proposed converter and its capacity to track the most extreme force working purpose of WES without rotor speed sensor in both enduring state and transient condition were exhibited by recreation result.

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