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DESIGN AND ANALYSIS OF THE CHAMELEON SCHEDULING ALGORITHM FOR RECONFIGURABLE COMPUTING

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A B S T R A C T

Conventional power generation is the source of widespread worry over the depletion of nonrenewable energy sources and the environmental difficulties that this would inevitably cause. As a direct consequence of this, an increasing number of people are gravitating toward renewable energy sources like as photovoltaic boards and wind generators. Wind power is being put to use for a vast array of applications, some of which include the charging of batteries, the pumping of water, the generation of electricity for homes, the heating of swimming pools, the operation of satellite power systems, and many more. However, despite the fact that they do not need any sort of upkeep and do not result in any kind of pollution, their installation costs are high in many different contexts. Wind energy is quickly becoming a more significant contributor to the total installed power capacity around the globe. In the field of wind energy, the PMSG-based wind turbine equipped with a variable-speed and variable-pitch control system are the most common type of wind power generator. This device is capable of operating either independently or while linked to an existing grid. It is necessary to have a complete understanding of the machine's modelling, control, dynamic, and steady-state analyses in order to obtain the maximum possible amount of power from the wind, researchers must make an accurate prediction of the machine's performance in either mode of operation. The complexity of the systems, the sensors required, the speed of combination, the cost, the breadth of effectiveness, the technology employed, and the popularity of the systems all vary. Multiple control computations are performed on the Wind Energy Conversion System (WECS) in order to produce maximum power in a variety of wind speed scenarios. This is done so that the system can respond appropriately. The purpose of this work is to suggest several methodologies for obtaining dynamic features from the WECS integrated grid. The first technique makes use of the Firefly Algorithm (FA) as well as the Artificial Neural Network (ANN) methods. Both are classification algorithms. By utilizing the most effective parameters for design, the design of the grid-integrated power system design was able to achieve a voltage THD of 11.47 percent.

1. INTRODUCTION

Wind energy is quickly becoming one of the most promising and competitive alternatives to traditional forms of energy production throughout the world (Sahin 2004, Global Wind Energy Council 2012, Global Wind Energy Council, 2014). The utilization of this energy is necessary for socioeconomic growth as well as economic success. In this day and age, renewable and other nonconventional sources of energy are gaining

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more attention than they ever have in the past. Wind energy conversion systems, often known as WECS, take use of the wind in order to transform mechanical energy into electrical energy (Bhutto et al., 2019). Control of the speed can be either fixed or variable when using WECS (Chhipa et al., 2021). Operating a wind turbine at varied speeds has a number of advantages, some of which include less strain on the gearbox (Polinder et al., 2006), higher annual energy collection, elimination of the requirement for blade control devices, and enhanced controllability (Hoseinpour & Barakati, 2012; Hossain & Ali, 2015). In order to keep up with the tremendous rise in size and technology of wind turbines, a control system that was far more complicated was necessary. This item investigates the power flow analysis of grid-connected WECS in a setting with a significant amount of wind variability. It's possible to get the maximum power out of a wind turbine if you control it the right way (Jain et al., 2015). Wind turbines are made up of two parts: one that monitors the DC connection voltage and another that determines where the turbine is producing the most electricity (Murti et al., 2020). In this chapter, a general introduction to the WECS is presented, including topics such as its dynamic modelling structure, classification, and control topology. During the course of the ongoing inquiry, a filter is being implemented between the WECS and the network in order to enhance power quality during interruptions, reduce total harmonic distortion (THD), power factor, islanding, and frequency, and reduce power factor (Sharma et al., 2020).

It is possible to use wind power to regulate either mechanical or electrical power; however, electrical power generation is one of the forms of energy generation that is expanding at one of the quickest rates in the world today (Farrok et al., 2020). Since at least three thousand years ago, people have been taking use of the power of the wind. Around the start of the 20th century, windmills were first put to use to grind grains and pump water. Prior to this time, these tasks were performed by horses. As a direct consequence of this, early phases of the development of modern industry saw a shift away from relying on wind power in favour of fossil fuel–powered engines and electrical networks, which offered a more reliable supply of electricity. The production of mechanical power and the creation of electrical power are the two primary applications for wind energy (Mahmoud et al., 2020). The flow of air across the earth is referred to as wind. Because of the sun's influence, the surface of the Earth is heated in an uneven manner. There is a wide range of rates of solar heat absorption over the surface of the Earth due to the differences in land and ocean cover. The atmosphere over land has a speedier ascent in temperature compared to the atmosphere above water. When air that is lighter and colder than the surrounding air rushes up and expands and rises above the air that is heated by the earth, winds are produced. Because the air cools off more quickly over land than it does over water, the winds switch directions as the sun goes down. Significant air winds are produced in the region surrounding the equator because it is exposed to a greater amount of sunlight than the land that is between the North Pole and the South Pole. Wind power is regarded to be a form of renewable energy due to the fact that it is a constant force in the environment (Saint-Drenan et al., 2020). Wind energy is produced when Hydrogen (H) is converted to Helium (He) as a byproduct of nuclear fusion in the centre of the sun (Wang et al., 2019). The sun generates heat and electromagnetic radiation as a byproduct of the fusion of hydrogen and helium, and this heat and radiation is sent into space in all directions. Even though just a minute fraction of the sun's rays reaches Earth, they provide most of the energy that sustains life on this planet. Wind power is a significant contributor to the global energy market and a well-established foundation for the development of cutting-edge methods of power generation. Wind power is a leading energy technology due to the technological maturity of the technology and the speed with which it can be implemented (de Falani, et al., 2020). There is no realistic upper limit to the percentage of wind energy that can be integrated into the electrical grid, making wind power a potentially limitless source of power. This is because there are no upper limits on the amount of wind energy that can be incorporated into the electrical grid (Ahmed et al., 2020). This allows for a much greater potential for its use. The Earth receives approximately ($1.8 * 10^{11}$) MW of solar power, but only about $3.6 * 10^{19}$ of this power is converted into wind energy, and approximately 35 percent of this wind energy is lost within 1000m of the Earth's surface, according to a study published in Nature Geoscience. The capacity of the world's wind farms to convert wind power into other forms of energy is approximately $1.26 * 10^{9}$ megawatts. Wind power has the potential to satisfy the total demand for electricity around the world, despite the fact that the global consumption of energy has increased by a factor of 20 in the past 20 years. Wind power is the process of harvesting the kinetic energy of the wind and converting it into a form that can be used by humans (Bănică, 2020). This process is referred to as "harvesting the wind." Systems that use the power of the wind as a source of propulsion are included in this category, as the name of the category suggests (Malmgren et al., 2021). To put it another way, the electricity is produced by a pair of wind turbines that are in close proximity to one another. A wind farm is currently being built offshore, and it is anticipated that it will be operational in the not-too-distant future.

1.1 Need for wind energy system

The depletion of environmental variables and fossil fuels served as a driving force behind the development of clean and safe renewable energy sources such as wind, solar, and hydropower. By incorporating WCS, the impact that the conventional electricity system has on the surrounding ecosystem can be reduced.

Traditional wind power systems, on the other hand, have a number of technological challenges that will need to be overcome before they can be integrated. All of this contributes to the fact that it is absolutely necessary to find solutions to the difficulties associated with overcoming the nature of distributed wind generators, concerns regarding the power quality of large wind farms, and the need to overcome difficulties associated with the integration of large wind farms (Bondalapati, 2001).

1.2 Growth of wind energy systems

Wind power is produced by harnessing the power of the wind to drive electric generators and carry out mechanical work such as milling and pumping (Snitchler et al., 2011). Wind power is an environmentally friendly and renewable form of energy, especially when compared to the combustion of fossil fuels. A wind farm is constructed from a large number of separate wind miles, all of which are connected to one another to create a bigger total.

Onshore wind turbines are a relatively inexpensive method of generating power when compared to coal and gas plants. Onshore wind farms have a considerable impact on the environment due to the fact that, in comparison to other types of power plants, they typically need to be dispersed across a wider geographic area and built in remote or wilderness locations. Wind turbines installed offshore are more powerful and stable than those positioned on land; nonetheless, the construction and maintenance costs of offshore wind turbines are higher. Small onshore wind farms have the ability to sell some of their electricity to the grid or to power regions that are not connected to the grid.

Wind is a fluctuating energy source, and as such, it is unable to create or distribute electricity when it is required. As a direct consequence of this, the amount of power generated changes significantly across very short time periods yet stays the same from one year to the next. Because of this, it cannot be used alone to produce a consistent supply of electricity; rather, it has to be combined with other types of power generation. In order to support the rising usage of wind power in a region, there is a demand for additional conventional power sources (such electricity generated by fossil fuels and nuclear power, for example). When wind output is low, demand can be lowered by employing various power management strategies (Akamp & Müller, 2013). These strategies include having dispatchable power sources, having adequate hydroelectric power with extra capacity, geographically spreading out power generation, and exporting and importing power to neighboring boring regions.

1.3 Wind energy conversion system and components

A wind turbine and generator are included in the setup, in addition to the necessary connection and control systems (Qiao & Lu, 2015). Wind turbines can be divided down into two primary categories: those with a vertical axis and those with a horizontal axis (Shanker, & Singh, 2012). The movement of the turbine is controlled by one or more blades in the majority of modern wind turbines. These blades can direct the turbine either downwind or upwind, depending on which direction the wind is blowing. The orientation of a wind turbine is the primary factor that determines whether it has a constant or variable speed when operating. Electronic electricity converters are necessary for variable-speed wind turbines because they are unable to supply their loads with a constant frequency and voltage without them (Tiwari & Babu, 2016). This is due to the fact that wind turbines with variable speeds produce more overall energy. The vast majority of turbine manufacturers employ reduction gears as a means of striking a balance between the requirements of high-speed three-phase generators and low-speed turbine rotors. Direct drive systems offer wind turbines a number of benefits, including high levels of reliability, low levels of maintenance requirements, and reduced overall costs. Direct drive systems are utilised by certain types of wind turbines. In recent years, a number of turbine manufacturers have moved toward employing the direct-drive method in their products. The squirrel cage type and the wound rotor type of wind turbines can now make use of synchronous generators, permanent magnet generators, and induction generators (Messaoud & Abdessamed, 2011; Basak et al., 2019). Previously, only induction generators were available. Two common varieties of generators used in wind turbines are known as squirrel cage induction generators and permanent magnet synchronous generators. There are benefits to be gained from utilising either of the two different types of generators. Induction generators, synchronous generators, and winding-field synchronous generators are the three distinct varieties of generators that are suitable for use in high-power wind turbines.

Utilizing connectivity devices allows for power regulation, a gentle starting process, and other connecting procedures to be carried out. Power electronic converters are often the gadgets that fall within this category. In current turbine inverters, the usage of forced commutation inverters, also known as pulse width modulation inverters, is prevalent because these inverters provide a steady output voltage and a consistent frequency. Inverters for wind turbines have been able to make use of both voltage source voltage-controlled models as well as voltage source current-controlled models. The use of dual PWM converters makes it possible for high-power wind turbines to establish a two way directional flow of electricity between the generator of the turbine and the utility grid. It is not out of the ordinary for a wind energy system to consist of blades and a tower, a rotor and gearbox, in addition to an alternator. The rate of wind speed rises proportionally with the height of the tower. It is utilized to raise the height of the rotor in order to collect a greater amount of power from the wind.

Rotor: It is constructed out of anything that resembles the wing of an aeroplane. When air moves across the blades of a wind turbine, it results in the generation of mechanical power.

Nacelle: This apparatus is integrated into the rotating rotor of the turbine itself and is situated at the very top of the tower that houses the turbine. The generator, the gearbox, and the motor are all examples of mechanical components that make up the turbine rotor. The nacelle is able to rotate in response to the direction that the wind is blowing in order to maximise the amount of wind energy that can be harvested.

Gearbox:In all other respects, the vast majority of machines have rotor speeds that are lower than one hundred revolutions per minute (rpm). To generate electricity, electrical generators require anywhere from 1,000 to 3,600 revolutions per minute in their motors. In order to generate electricity from a turbine, gearboxes are constructed with the capability of increasing the low speeds of the turbine's rotor to high speeds.

Alternator: Alternators are devices that directly convert mechanical energy, such as wind potential, into electrical energy. However, among all of the electrical machines that are used for maintaining a constant speed in wind turbines, the Squirrel Cage Induction Machine (SCIM) is the most well-known. Additionally, it is one of the most significant sorts of wind turbine generators that is now on the market. The rotor of the wind turbine is connected to the capacitors of the bank, whilst the stator of the bank is connected directly to the grid. This type of machine has a few drawbacks, including a poor efficiency in the system that converts energy, greater maintenance expenses, and a restricted capability to control both active and reactive power. It should come as no surprise that the Doubly Fed Induction Machine, often known as the DFIM, is one of the wind turbine machines that is utilised the most. Roughly half of all wind turbine systems currently in operation make use of this machine's variable speed technology. This helps to lower drive train mechanical stress as well as power oscillation, all while increasing the power that can be mechanically collected. When contrasted to SCIM, DFIM utilises pitch control to restrict the quantity of wind energy that can be captured at higher wind speeds. This is done in order to maximise efficiency. Because DFIM decreases mechanical stress and increases maximum power point tracking (MPPT) for speed controller techniques, it is now able to regulate both active and reactive power with more flexibility. It has been pointed out that the use of brushes in double-fed induction machines (SCIMs) is a disadvantage for wind energy conversion systems, despite the fact that SCIMs are more durable and require less maintenance.

Synchronous generators:

The fundamental advantage of the design of the machine is that it may deliver reactive power to other components of the power system that demand it. This capability is found in sophisticated synchronous generators. In most cases, a synchronous generator is used in wind-diesel hybrid systems. This generator is normally linked to the diesel engine. Synchronous generators that are put on a wind turbine need to have rigorous controls applied to them so that the rotor speed does not go over the synchronous speed when turbulent circumstances are present. In addition to this, the utilization of spring-mounted or damper-mounted gearbox assemblies is required in order to contribute to the reduction of turbulence. This is a requirement in order to help with the reduction of turbulence. When it comes to applications involving smaller size ranges, synchronous generators typically have a higher price tag than induction generators do. Synchronous generators, to put this another way, are more prone to malfunctioning than asynchronous ones are.

Permanent Magnet Synchronous Generator (PMSG):

As can be seen in Figure 1, a grid-connected PMSG is required in order to connect direct-drive wind turbines to the electrical grid (Lin, et al. 2011; Jayalakshmi & Gaonkar 2012; Seixas et al., 2014). The following is a condensed version of the advantages that PM machines have over machines that are electrically excited:

- Enhanced capabilities in terms of both energy production and efficiency.
- Excitation of magnetic fields does not call for the use of any supplementary power source. The thermal characteristics of the PM machine have significantly improved as a result of the elimination of field losses.
- Increased reliability is achieved through the elimination of mechanical components such as slip rings.
- A greater power-to-weight ratio as a direct result of the reduced overall weight.

The following is a condensed list of the drawbacks associated with PM machines:

One of the most significant drawbacks of utilizing this material is that it loses its magnetic properties when subjected to high temperatures.

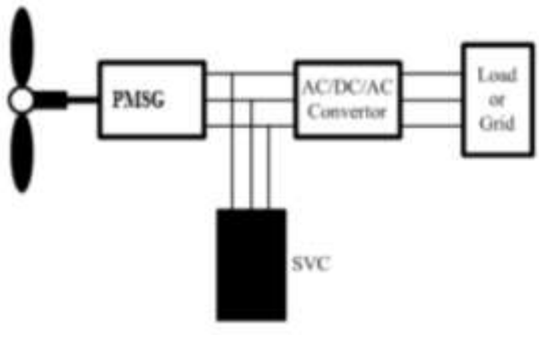


Figure 1. The General Arrangement of the Full Variable – Speed System Using PMSG

To put it another way, particle matter (PM) has become more desirable as a result of improvements in its performance as well as a decline in the cost of the material. As a result of recent developments in technology, direct-drive wind turbines are increasingly reliant on PM machines that are outfitted with full-scale power converters. This trend is expected to continue. Consider putting variable speed concepts into action, such as those that involve a full-scale power converter and either a single-stage or multiple-stage gearbox drivetrain, so that you can cut down on the amount of money you spend on your annual energy bill. An illustration of this would be PMSG systems that either have multiple-stage gearboxes or single-stage gearboxes because both types of gearboxes are in high demand on the market (Qiu et al., 2011; Qiao & Lu, 2015, Prince et al., 2021).

2. LITERTURE SURVEY ON GRID INTEGRATED WIND ENERGY CONVERSION SYSTEM

The idea that wind power can be utilised in a diverse range of ways that are not only good for the environment but also socially and economically acceptable has gained widespread acceptance in recent years. As a result of the diminishing availability of fossil fuels and the growing significance of concerns regarding the environment, there has been an increase in the utilisation of wind power (Diaz-González et al., 2012; Dalala et al., 2013). Wind power generation has been determined to be the renewable energy source with the highest annual growth rate (Jain et al., 2015). This is due to the fact that producing electricity with wind is not only beneficial to the environment but also economical. Wind energy conversion systems, abbreviated as WECS, are the devices that are currently responsible for transforming the kinetic energy of the wind into useful forms of power. The mechanical energy produced by wind turbine generators and windmills is then converted into electrical energy (Blaabjerg et al., 2012, Blaabjerg & Ma, 2013). This kinetic energy could be used for a variety of purposes, including pumping water, grinding grain, or powering machinery. Wind turbines garner a lot of attention when it comes to the topic of meeting the targets for renewable energy that have been set by governments all over the world. Wind farms that contain turbines with multiple megawatts of capacity are able to accomplish these goals. In the past year, offshore wind resources have become increasingly more important. Wind turbines on land have been limited in their ability to generate renewable energy due to environmental regulations and controversy; however, offshore wind turbines have a significantly greater potential to do so. Offshore installations require the construction of substantial platforms that are capable of supporting the combined weight of the structure and the wind energy conversion system. Efficiency and dependability aren't the only factors that need to be taken into consideration for offshore installations. The security of offshore installations is another important factor that needs to be taken into account. The utilisation of wind power in the generation of electrical power is becoming increasingly recognised as a technology that is both beneficial to the environment and economically advantageous. The generation of wind power has witnessed rapid expansion over the course of the last decade, earning it this honour as a result. This chapter covers a wide variety of wind turbine systems, each of which has its own set of distinguishing qualities as well as applications. This introduction to wind energy conversion will cover topics such as how wind energy is generated, what components make up a wind energy system, how the system operates, and what kinds of wind turbines are available (WTs).

2.1 Wind energy conversion system

As a result of the growth of the global economy, there is an increasing demand for dependable sources of energy. Because of how favourable the conditions currently are, it is feasible to meet the ever-increasing demand for electricity by harnessing the power of the wind. Wind power has reached a point where it can now be routinely used by utilities as a source of energy generation. This was previously not possible. The improvements that have been made in the industry are to blame for this level of readiness. Reliability, availability, and maintainability of WTG are crucial factors that must be met before wind power can be used extensively. Efficiency in the conversion of wind energy is also very important.

Pujari et al. (2023) have compiled a list of the aspects of WECS that pose the greatest amount of difficulty. This report examines the most recent developments in wind energy conversion systems and discusses them in detail. This course covers a variety of topics, including the categorization of systems, the various options for generators, as well as the social and environmental benefits of these systems. In addition to these topics, a report on the progress of Canadian and IEEE1547 interconnection standards will be presented. This report will cover issues with connectivity for dispersed resources such as wind and electric power systems and hybrid power systems, and it will discuss how the standards are progressing.

A generator that can change its speed and is connected to the grid WECS adhere to the straightforward method of control proposed (Raouf et al., 2023) for this kind of system in order to achieve the highest possible output power. When it comes to getting the most power out of a wind turbine, the Maximum Power Point Tracking (MPPT) system is the way to go. This system only makes use of direct current (DC) link electricity. MATLAB-SIMULINK was used to develop models of MPPT and search methods, as well as DC-DC and DC-AC converters and PWM controllers (Nayanar et al., 2016). The simulations indicated that the system would be capable of harvesting the maximum amount of wind power and precisely distributing that power throughout the system.

According to C. Xia and colleagues direct-driven WECS equipped with three-level inverters have neutral-point potential balancing. During this training session, the direct-driven WECSs were supplied with power by a three-level (TL) chopper that was positioned in front of a diode-clamped inverter. By utilising a switch-signal phase delay control, also known as SSPDC for short, we were able to achieve a state of equilibrium with regard to the NP potential of the TL inverter. In addition to tracking the maximum power point, the controller that was developed for the boost chopper was also used for this purpose. It contains two PI regulators and was used for both of these purposes.

The research of Toledo and colleagues looked into the most recent developments in wind energy conversion systems. It would be helpful if you could provide a citation for this. Conducting research on the various aspects of the process that are pertinent to the transformation of wind energy is necessary if one wishes to achieve maximum efficiency.

This study ought to centre on the technical aspects of offshore wind turbine nacelles in addition to the most recent advancements in the field of renewable energy technology. In this article, the technological obstacles, current research and development trends, and potential future study areas for reducing the weight and volume of the nacelle are discussed. This page also includes, for your research and consideration, a comprehensive review of the more conventional methods for generating electricity using wind power.

Both vertical and horizontal axis wind turbines, abbreviated as VAWT and HAWT respectively, are the most common types of wind turbines (VAWT). Activities conducted downwind as well as those conducted upwind are both possible with a HAWT having two or three blades. This HAWT gives you the option to operate at either a constant or a variable speed depending on your needs.

In power plants that operate on renewable energy sources, induction machines are utilised quite frequently. This is due to the fact that not only are they easily accessible, but they also have a reasonable price point. However, static and reactive compensating capacitors can be used in conjunction with large power systems to correct power factor and reduce harmonics. Utility grids have the ability to control voltage and frequency. Asynchronous generators are by far the most common type of generator used in hydroelectric and wind power plants. Depending on the application, they can also be used in prime movers that are powered by diesel, biogas, or natural gas. Alternatively, they can be powered by gasoline or alcohol-based fuels (Farret & Simões, 2006). An induction generator can be utilised not only as a generator but also as a motor, and it does an excellent job of fulfilling both of these roles. In addition to being the most cost-effective generators currently available on the market, these models feature a sturdy construction that enables them to withstand short circuits.

There is a connection between Sliding Mode Control (SMC) and Field Oriented Control, which is based on dual-stator induction generators (FOC). 11] (FOC). The nonlinear properties of wind turbines that are fitted with electric generators necessitate some interesting control requirements for wind energy conversion systems (WECS) that are connected to the standard electrical grid. The SMC is a robust nonlinear approach that utilises discontinuous control in order to bring the system state trajectories into alignment with a predetermined sliding surface. Getting this done might be possible through the SMC. It is frequently used in situations in which the modelling parameters are uncertain or when there are interruptions from the outside.

Djurovic et al. developed condition monitoring systems for induction generators that are used in wind turbines with electrically asymmetrical rotors. These monitoring systems are used in wind turbines. In order to verify the findings of the study, a time-stepping electromagnetic model as well as experimental data gathered from two distinct test rigs were utilised. The accuracy of analytical expressions that characterise the variation in fault frequency with operating speed has been confirmed by measurement, which paves the way for real-time tracking of fault frequency within a system. These expressions can be found in this section of the article.

Magnets can be used in place of the excitation windings in synchronous machines due to the lower cost of the magnets and the improved magnetic material they use (Geng & Xu, 2011). The pole pitch on conventional generators is significantly greater than that of permanent magnet excitation machines. Because of this, these machines can be constructed to rotate at speeds ranging from 20 to 200 revolutions per minute (r/min), depending on the rated output of the generator. r/min stands for revolutions per minute. Multi-pole permanent magnet generators may or may not be included in the products that a given manufacturer of wind turbines offers, depending on the nature of their business (e.g. Jeumont, Lagerwey). Changing the speed of the turbine's rotation when the wind is blowing is one way to maximise the amount of energy that can be extracted from the wind.

A method for measuring the maximum power point was developed by Xia et al. in order to determine the maximum power point of WECS that make use of permanent magnet generators. Using this method, one can determine the amount of power that the WECS produces.

It is anticipated that systems that convert wind energy into a form that is usable will benefit from the addition of a device that detects their peak power point. These systems use permanent magnet synchronous generators. During training, an algorithm can be used to quickly discover the ideal relationship that should exist between the voltage at the rectified DC output and the current. By implementing innovative P&O practises, it is possible to reduce the impact of variable wind conditions to some extent. In order for the system to operate in a manner that is congruent with this hypothetical relation, it was made operational.

PI control is essential in order for a process to maintain a constant output over the course of its lifetime. This suggests that the procedure is operating as it should at the present time.

A PI-based control design approach has become available thanks to the work that was done by Hwas et al. for the purpose of managing the pitch angle of blades on variable-speed wind turbines. When calculating the PI enhancements, one of the possible approaches can be analytical, while the other can be based on simulation. Both of these approaches are distinct from one another. It has been demonstrated through simulations that both of the PI methods have the potential to produce favourable outcomes. In order to construct an experimental test bench in a laboratory and evaluate the performance of the proposed controller in both steady and transient modes, DSPACE 1104 cards were utilised as the primary building material. According to the findings of the tests, FFOPI+I over FOPI controllers proved to be very effective and reliable across the broad spectrum of wind speeds that were evaluated.

Experimentally enhanced fuzzy-fractional order PI+I controllers were developed by Beddar et al. for grid-connected variable-speed wind energy conversion systems. Both a nonlinear load and an ACDC/AC converter that was connected to the grid needed to be controlled using pulse width modulation (PWM). The control system of the MSC is designed to generate the maximum amount of power possible, regardless of the wind speed.

2.2 Mathematical modeling of permanent magnet synchronous generator

It is possible that the robustness of a variable-speed wind turbine could be significantly improved by installing a direct-drive permanent magnet synchronous generator (PMSG). PMSGs have garnered a great deal of interest in the field of wind energy applications due to their capacity to function at high power factors while still preserving a high level of efficiency. The variable wind speeds will cause the output of a PMSG to have an amplitude and frequency that are not stable. Inverters are required for all of these different approaches in order to keep the dc voltage at a constant level. The following expression can be used to describe the voltage produced by the generator in terms of the d-q rotating reference frame:

Equation:

$$V_{ds} = -R_s i_{ds} + w_r L_{qs} i_{qs} - L_{ds}\frac{di_{ds}}{dt} \quad (2.1)$$

$$V_{qs} = -R_s i_{qs} - w_r L_{qs} i_{qs} + w_r \partial_f - L_{qs}\frac{di_{qs}}{dt} \quad (2.2)$$

Where,

R_s- the stator resistance

i_{qs}, i_{ds}- the stator direct and quadrature currents

∂_f- the rotor flux and

L_{qs} , L_{ds}- the stator direct and quadrature inductance

The electromagnetic torque is expressed as

$$T_e = \frac{3}{2}P\left[\lambda_f + \left(L_{ds} - L_{qs}\right)i_{ds}\right]i_{qs}$$

The machine equivalent mechanical equation is

$$T_m - T_e = J\frac{d\omega_m}{dt} + B\omega_m$$

Where, H are the inertia constant and equals H = $\frac{1}{2}(\frac{Jw_b^2}{P_p^2 P_b})$ and friction coefficient in per unit equals B_{pu} $=(\frac{Bw_b^2}{P_p^2 P_b})$

The mathematical model using these methods and improving the performance of the grid integrated WECS.

3. ANALYSIS OF WIND ENERGY CONVERSION SYSTEM USING FA-ANN TECHNIQUE

Solar, wind, and hydropower are examples of renewable energy sources that produce no harmful byproducts and are simple and inexpensive to deploy. Oil and natural gas have the potential to take the place of more traditional forms of energy. However, as a result of overgrowth, both the output and validity of these systems have decreased. Inadequate alternating current (AC) networks have proven to be troublesome for the operation of big wind turbines because to stability and power quality issues. This article provides an explanation of an alternative wind turbine drive-train layout that utilises the adaptive strategy and combines a number of Permanent Magnet Synchronous Generators (PMSGs) with a cascaded multilevel converter. Combining Artificial Neural Networks (ANNs) and Firefly Algorithms results in a method that is highly flexible (Allen & Kennedy, 2002; Auyeung et al., 2003). The ANN's capacity to acquire new knowledge is improved with the utilisation of the FA. As a consequence of this, it is possible to reduce the switching losses that occur on cascaded multi-level inverters. The adaptive method, which is computed utilising a PID controller, is utilised in the process of computing the WECS stability study.

3.1 Problem formulation

To achieving the most optimal controller gain settings, the FA-ANN method is applied. To conduct an analysis of the actual power being produced by the proposed system, a PID controller is used. To begin, an inaccurate power value is input into the PID controller, and the gain settings are adjusted so that they are accurate. The method is optimised through the application of the FA-ANN approach. The error data is used as a source of information for the gain parameters kp (Kp), Ki (Ki), and Kd (Kd) (Kd). To achieve synchronisation of the grid as well as the transformation of the coordinates, an integrated phase-locked loop is utilised (PLL). This approach's internal control loops make it possible for it to respond quickly to transients and to achieve excellent static performance in general. Grid currents can be broken down into d-axis and q-axis currents, which enables active and reactive power to be adjusted in a manner that is independent of one another. By utilising this method of control, one is able to realise both a high power factor and sinusoidal grid currents. In order to calculate the total amount of active and reactive power that a wind energy conversion system produces, equations are required.

$$P = \frac{3}{2}\left(E^d i^d + e^q i^q\right) + \left(R^d i^d + R^q i^q\right) + \left(L^d i^d + L^q i^q\right)$$

$$Q = \frac{3}{2}\left(E^d i^d - e^q i^q\right) + \left(R^d i^d - R^q i^q\right) + \left(L^d i^d - L^q i^q\right)$$

The d-axis reference is usually obtained from DC-link voltage controller.

$$P = \frac{3}{2}\left(E^d i^d\right)\left(R^d i^d\right)\left(L^d i^d\right)$$

$$Q = -\frac{3}{2}\left(E^d i^q\right)\left(R^d i^q\right)\left(L^d i^q\right)$$

The three-phase inverse output is denoted by the letters i_{abc}. Control of a cascaded cascaded H-bridge MLI converter is achieved by first determining the three-phase actual current, then determining the reference current, and finally producing the ideal pulses. This is done in order to ensure that the controlled cascaded H-bridge MLI converter is able to produce the best possible pulses. The performance of the cascaded H-bridge MLI converter was improved by increasing the ideal gain parameter of the converter. This improved the performance of the converter in both control loops. The measured values are additionally affected by the PLL loops. The utilisation of three PID controllers within the framework of the proposed system enables it to function in complete congruence with the grid. Setting the zero point as the reference point on the q-axis is one way to arrive at the power factor of one. As a result of the superior dynamic responsiveness of the system, switching pulses for inverters can be generated by the system itself. As a result of the PLL, the grid harmonics and phase shifts that would normally have an effect on the source parameters are eliminated. Putting an LC filter between the inverter and the grid helps improve power quality while also lowering the number of harmonics that are produced by the WECS system.

3.2 Modelling of wind energy conversion system

There are many different forms of renewable energy, but the one that is expanding at the greatest rate is wind power. A variable speed wind turbine (VSWT), is able to harness the maximum amount of power regardless of the speed of the wind. There are a number of different designs that can handle the variable-speed duty of the PMSG wind turbine framework (Hong et al., 2011). These designs include staggered converters and two-dimensional converters. Wind turbines are typical devices that are used to create energy by harnessing the power of the wind. Kinetic energy, denoted by the symbol E=W=Fs, that was put in to bringing an object from a state of rest to a certain distance, denoted by the symbol s, while the acceleration is held constant. The following equation can be used to describe Newton's second law: (3.1).

$$F = ma \qquad (3.1)$$

The actual wattage of the rotor blades' mechanical power is calculated by subtracting their upwind and downwind powers from their total value in the calculation (3.2).

$$P^w = [\tfrac{1}{2}.pAv_w.(v^2{}_u - v^2{}_d)] \qquad (3.2)$$

Where $v^2{}_u$ represents the velocity of the rotor blades as they enter the upwind direction in metres per second, and $v^2{}_d$ represents the velocity of the rotor blades as they exit the downwind direction in metres per second, respectively. These two speeds are used as the foundation for the calculation that determines the ratio of the blade tip speed. Now, with the mass flow rate serving as a point of reference:

Equation (3.3), can be written as,

$$pAv_w = (\frac{pA(v_u - v_d)}{2}) \qquad (3.3)$$

Where v_u is the average of the velocities that the rotor blades of the turbine experience while they are entering and exiting the machine. The wind turbine has a tip speed ratio that can affect it in a variety of ways. The symbol Ts stands for ratio between the wind speed blowing downwind to the wind speed blowing upwind, which is defined by the equation (3.4).

Ts= v_d/v_u or Ts=blade tip speed/wind speed (3.4)

In the following section, we will discuss the WECS stability study that was conducted using adaptive FA and ANN modelling techniques.

3.3 Analysis of ann algorithm based grid integrated wecs

The discussion in this article is focused on a cascaded multilevel H-bride inverter stability analysis using the ANN algorithm. There is an option for an inverter-based wind energy conversion system like the one shown in figure 2. The WECS consists of the elements Rb, Lb, and Vdc. Components such as these are utilized in order to symbolically represent the DC link voltage, in addition to the resistance and inductance. The PMSG has a connection to WECS as part of its mandate to play a part in laying the foundation for the region. It is possible to eliminate the need for gear or drive train systems in order to reduce the overall cost and size of the system by employing PMSG-related WECS. This will allow for the elimination of the need for gear systems. The PMSG initiator, which is a variable-speed generator, is activated with the assistance of data regarding the wind speed. Dynamic Braking Resistors, also known as DBRs, are an excellent choice for the design of synchronous generators because they do not need to be magnetised by a current. By utilising the DBR, alternating current can be converted into pure direct current, which is then free of any unwanted harmonics. This is possible because of the DBR. It is possible to exert control over the torque and, as a result, achieve maximum power levels when the boost converter and the DBR are responsible for supplying the DC voltage. The smoothing capacitor known as the Cdc is what is utilized to stop the DC voltage from increasing.

This article presents a discussion on the ANN algorithm-based cascaded multilevel H-bride inverter stability analysis. Figure 2 illustrates how the wind energy conversion system works by using an inverter with multiple levels that are cascaded together. This diagram of the WECS illustrates the resistance Rb, the inductance Lb, and the DC-link voltage Vdc. All three of these characteristics are shown. The PMSG, which is responsible for determining the region's basis, is connected to the WECS grid. The complexity of the system, as well as its overall size and cost, can be decreased through the utilisation of PMSG-related WECS, and this can be accomplished without the utilisation of gear or drive train systems. The PMSG initiator, which is a variable speed generator, is activated after a comprehensive collection of wind speeds is made.

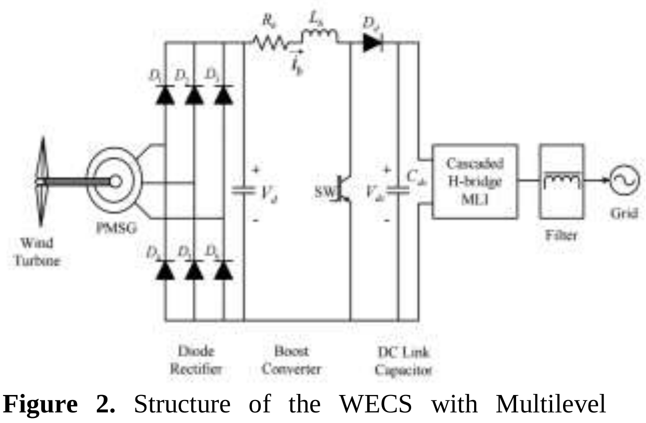


Figure 2. Structure of the WECS with Multilevel Inverter

The Dynamic Braking Resistors, also known as DBRs, are a pattern that is suitable for use in synchronous generators because they do not call for a magnetising current. It is possible to get rid of harmonics by converting the AC into DC, which is why the DBR is used in the process. Utilizing both a boost converter and a DBR, which are connected to one another, is required in order to achieve the highest possible DC voltage. Utilizing a smoothing capacitor like Cdc helps reduce the DC voltage swell that can occur.

The cascaded H-bridge Multilevel Inverter is responsible for the current variation of the system's output voltage, which consists of five levels (MLI). It is used to develop the presentation by keeping the regulator's expansion limit and causing the most favorable pulses for the cascaded H-bridge MLI to be created. Both of these things are necessary in order to develop the presentation. In order for this to be successful, the expansion restriction must be maintained at all times. The WECS gain optimizer, in conjunction with another algorithm, is used to optimize the gain parameters of the cascaded H-bridge multilevel inverter.

3.4 Analysis of wecs using adaptive fa -ann technique

A new control strategy has been implemented here in order to improve the power quality provided by WECS. The minimization of WECS consonants can now be improved by utilising a combination of FA calculation and an ANN system. This was not previously possible. It is common practise to make use of the cascaded H-bridge multilevel inverter in order to enhance the ANN strategy for controlling quality concerns regarding the WECS force. In the section that follows the WECS, a calculation of the FA is provided for your reference.

3.4.1 Introduction of Fire Fly algorithm

A model of a firefly was crafted by Yang. Because of their alluring appearance, fireflies are most active at night. They enjoy living in warm environments, and because of their allure, they tend to be most active during the night. There are a number of fascinating aspects related to flame flies, such as the following:

- A model of a firefly was crafted by Yang. Because of their alluring appearance, fireflies are most active at night.
- They enjoy living in warm environments, and because of their allure, they tend to be most active during the night.
- There are a number of fascinating aspects related to flame flies, such as the following:

The bioluminescence technique is in charge of the glinting light of fireflies. There are a couple of theories about the aim and position of blasting light in fireflies' life cycle yet huge quantities of them converge to mating stage. The simple focus of bursting light is to attract the mating associates. The case of these melodic flashes is fascinating and it relies upon the mind-set of flashes, rate of blasting, and proportion of time for flashes are recognized.

3.4.2 Proposed Methodology

The research has been undertaken in the following stages ϖ MATLAB /SIMULINK 7.10.0 is R2010a simulation of Grid integration of Wind Energy Conversion System using FA-ANN algorithm. Performance metrics like PMSG active power, PMSG reactive power, DC-link voltage, wind speed, and THD.

3.4.3 Classification of FA

The algorithms used by Firefly have been through a variety of iterations over the course of their development. Tuning, also known as adaptive parameter control, is a technique that has been utilized in the search for the optimal combination of parameters. A number of different modified and combined firefly algorithms are presented in Figure 3.

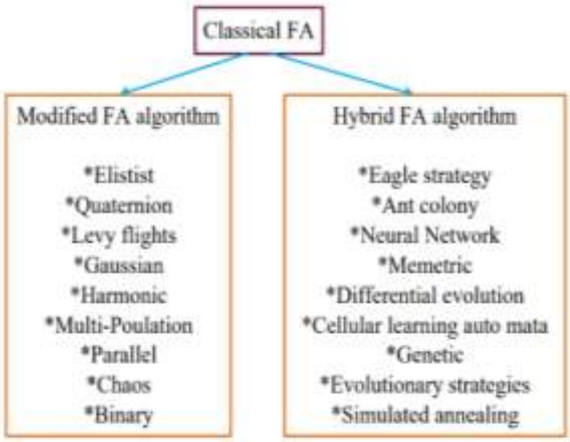


Figure 3. Classification of Firefly algorithm

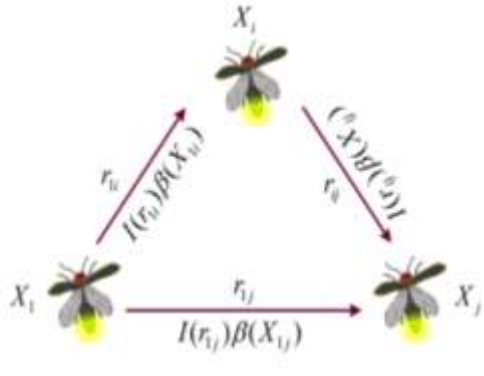


Figure 4. A Conceptual View of the Firefly Algorithm which includes locations X, Distance r, Brightness I(r) and Attractiveness β(r).

3.4.4 Adaptive FA-ANN Technique Based Cascaded H- Multi Level Inverter Using Grid Side Variation

In this proposed scheme, the Adaptive FA-ANN strategy has used out the control parameters improvement for WECS structure dependent on the Cascaded multilevel inverter utilizing matrix side variety (Figure 4). The Cascaded Hbridge multilevel inverter can coordinate the controlling of the exchanging problem and matrix side variety. The proposed methodology is the mix of FA and ANN procedure. The FA calculation is to build up the information of ANN. The FA advancement calculation favours the most ideal readiness dataset to direct the ANN for improving the learning introduction. ANN incorporates three layers, for example, input, covered up, and yield layers. The information layer contains various hubs that are plucky by methods for the informational index. Each hub incorporates related loads to the whole hubs in the following layer and too one disposition identified with the same hubs of the following layer. Inclination hubs envelop a yield of one hub and they are identified with the whole hubs of their layer. The loads on the relationship from inclination hubs are known as predisposition loads. The whole loads are evaluated to give the theoretical of this hub, and a short time later the foundation task of this hub is determined. There are various classes of the foundation task like a stage task, a signed assignment and a sigmoid undertaking. There are numerous classes of the foundation task like a stage task, a signed assignment and a sigmoid errand. The customary foundation task is a sigmoid assignment which is appeared in condition as follows.

$$f(x) = \frac{1}{1+e^{-x}}$$

The input data are specified by the equation x.

The number of information sources and the number of yields that can be reliably derived from a dataset are what determine the records that make up hubs in both the information and yield layers. The number of hubs that are contained within a hidden layer can be expressed as follows, in accordance with the Kolmogorov hypothesis:

*Hidden nodes = 2 * Input +1*

A fake neuron is the basic preparing part and its inside modifiable confinements are recognized as association loads. Fake neurons weight, total and limit approaching signs are utilized to create yield. Data is assembled in the intensity of the interconnections or loads and the edges. The most critical goal of ANN is to decide a gathering of association loads that reduce the shortcoming task. The system is an open couple of yield information and the issue for the time of learning. The procedure depends on the FA. The calculation is gotten from the qualities of the fitter species. It contains successful rummaging strategy like remain alive and scattered in the improvement chain.

In the following section of this article, an in-depth analysis of the ANN is presented for your perusal. One of the neural network architectures that is used today in the most common applications is the multi-layer feedforward network with the back-propagation learning algorithm. This architecture is used quite frequently. The architecture of a neural network typically consists of the standard components of an input layer, an output layer, and a hidden layer. Figure 5 presents an illustration of the training structure for ANNs. Back propagation is the name of the algorithm that is used during the training process for the neural networks.

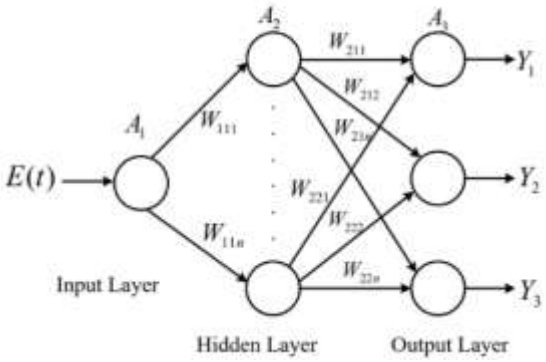


Figure 5. Training Structure of ANN using Proposed Adaptive

As can be seen, the weights for both the input and the output layers have been assigned in this illustration. W111 and W11n are the weights that go from the input layer to the hidden layer. W211 and W212 are the weights that go from the hidden layer to the output layers, and W221 and W222 are the weights that go in the opposite direction. The outputs of the node are denoted by the letters Y1, Y2, and Y3.

After that, an algorithm known as back propagation is applied to the training of the neural network. The following is an outline of the steps that make up the training algorithm.

3.4.5 Proposed Cascaded H-bridge 5-Level multilevel Inverter

The proposed method is utilized by multilevel inverters known as cascaded H-bridges (CHB) (5-level).

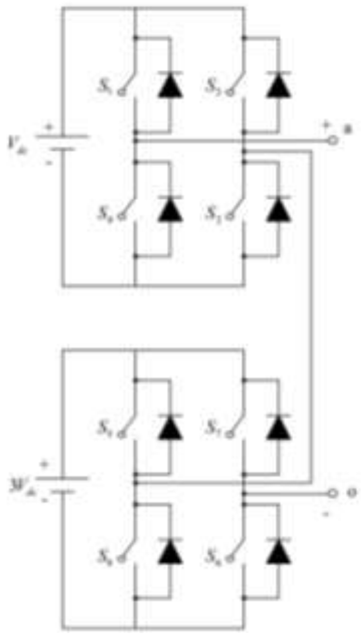


Figure 6. Five Level Cascaded H – Bridge Multilevel Inverter

Figure 6 is a schematic representation of an H-bridge multilevel inverter with cascaded H-bridge input DC sources. There are a total of nine possible output stages when using Vdc and Vdc 3, including 4Vdc, 3Vdc, 2Vdc, and Vc.

3.4.6 Control Strategy

The control strategy for a grid-connected WECS is first deconstructed into its dynamic properties, which are then used to describe the control strategy. Studying the flow of electricity through the grid can be done with the help of the WECS. To put it another way, utilising WECS is a choice that results in significant cost savings. The power that is generated by the WECS is sent to the grid through the DBR. It was necessary to use a rectifier in order to change the alternating current into direct current (DC). When you already have access to the DC power, using a boost converter will enable you to extract the maximum amount of useful energy from the DC power. The maximum amount of power that can be drawn from the cascaded H-bridge MLI is then used to draw from nine different levels of power (Figure 7). Improving the controller components is one way to increase the likelihood that the project will be successful. The performance of the cascaded H-bridge MLI has undergone further enhancements, and the generation of optimal pulses has been completed. The analysis takes into account not only the real power but also the reactive power, the regulation of the voltage, and the total harmonic distortion. In this way, a proposed controller is utilised in order to conduct an analysis of the control system's power regulation and voltage regulation blocks. Figure 7 illustrates the control structure that is utilised by this method.

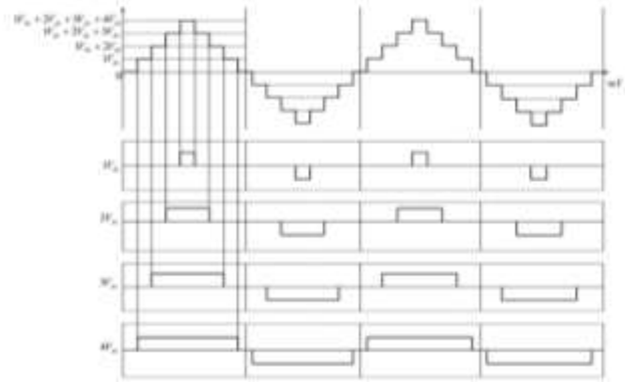


Figure 7. Output voltage waveform of five-level cascaded H-bridge multilevel inverter

Because each control strategy is a separate and independent undertaking, it possesses its own one-of-a-kind set of parameters. In a power control strategy, the real power, denoted by Pm, is computed using the PLL method, and the result is compared to the reference power, denoted by P*.After this has been accomplished, the error values are computed and recorded alongside the factor (E). Using the FA-ANN technique, the gain parameters of the controller are optimized for optimal performance. We are able to calculate the system's true output power by utilizing a PID controller (Figure 8).

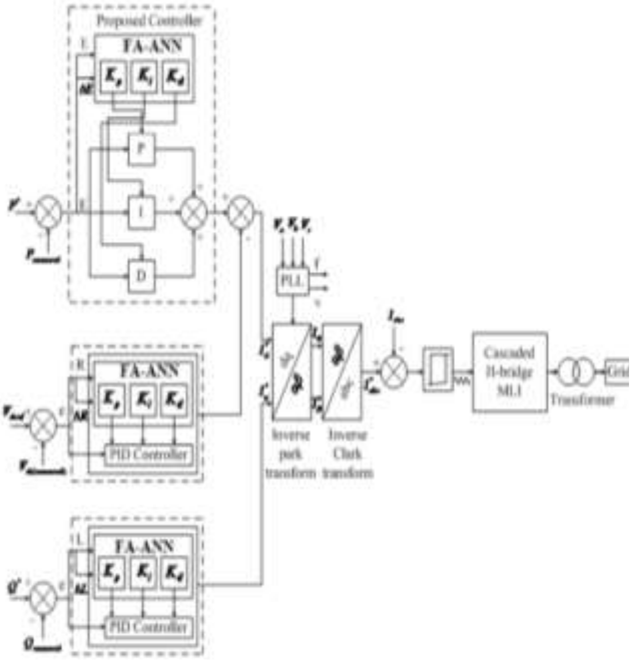


Figure 8. FA – ANN with PID Controller

At first, the PID controller takes the error value of the power as its input, and then it tunes the gain parameters to their optimum levels.

3.4.7 Power and Voltage Control loops

The FA-ANN method is utilized in order to achieve optimal results with the process. Input for the gain parameters kp (Kp), Ki (Ki), and Kd (Kd) are taken from the error values (Kd). After that, the gain parameters and inputs that work best are figured out. As an input, the PID controller takes into consideration the optimized values for the gain parameters. After this step, PID controllers are able to be fine-tuned, which ultimately results in an output that is more accurate and efficient. In the same way, we are working on the other blocks, and their performances are being evaluated. Using these three blocks, it is possible to generate cascaded H-bridge MLI control pulses and investigate their dynamic properties. The pulses of a cascaded H-bridge MLI that has been optimized for connection to the WECS grid are being studied. The d-axis and q-axis current components of the inverter are responsible for controlling the instantaneous reactive and active power exchange that occurs between the DC link voltage and the grid. Inverters are responsible for producing square waves with a high frequency. The synchronized reference frame for the direct current quantities of the control variables is depicted in figure 3.4. Grid-side converters can now be easily filtered and controlled thanks to a new method that has been developed. In addition to this, the PID regulator is superior to others in its ability to control DC variables. The phase lock loop (PLL) is then used to obtain the grid angle for the transformation.

A phase-locked loop is utilized in order to accomplish grid synchronization as well as coordinate transformation (PLL). Internal control loops of this strategy ensure a rapid response to any transients and a high static performance. It is possible to separate the d-axis grid current from the q-axis grid current, which enables independent control of the system's active power and reactive power. By utilizing this method of control, one is able to realize both a high power factor and sinusoidal grid currents. In the process of converting wind energy into usable forms, equations are utilized to ascertain the total amount of active and reactive power that is produced.

$$P = \frac{3}{2}(E^d.i^d + e^q.i^q) + (R^d.i^d + R^q.i^q) + (L^d.i^d + L^q i^q)$$

$$Q = \frac{3}{2}(E^d.i^d - e^q.i^q) + (R^d.i^d - R^q.i^q) + (L^d.i^d - L^q i^q)$$

4. ANALYSIS OF GRID INTEGRATED WECS USING FIRE FLY OPTIMIZATION ALGORITHM RESULTS

Figure 9 shows MATLAB/SIMULINK model of the FA-ANN method with cascaded H-bridge multilevel inverter, and Table 1 shows implementation parameters of the PMSG using FA-ANN method.

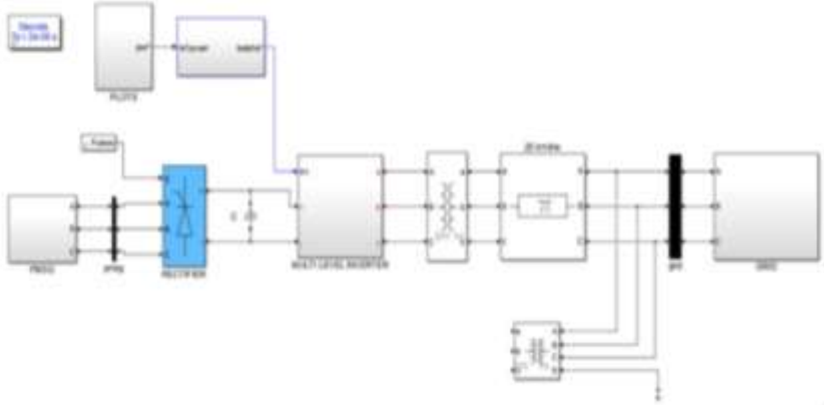


Figure 9. MATLAB/SIMULINK model of the FA-ANN method with cascaded H-bridge multilevel inverter

Table 1. Implementation parameters of the PMSG using FA-ANN method

Description of parameters	Values
Rated wind speed	12(m/s)
Base rotational speed	1.2 (p.u)
Nominal mechanical output power	605.142 (W)
Stator phase resistance	0.18 (ohm)
Armature inductance	0.0167 (H)
Pole pairs	4
Rotor type	Round
Flux linkage	0.0714 (v_s)
Torque constant	0.4286 (N_m)
Inertia	0.00062J(kgm^{-2})
Friction factor	0.00030 F(Nms)

4.1 Analysis of normal wind speed

Figure 10, which depicts the device in normal operation and demonstrates how it works, includes an illustration of the rotor and the wind speeds.

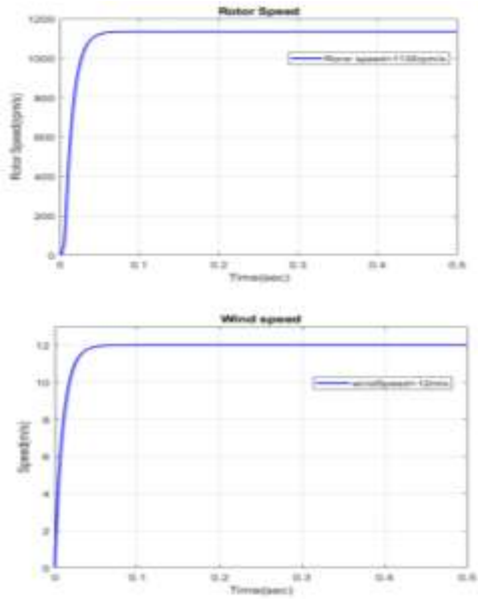


Figure 10. Rotor speed and wind speed in normal wind speed condition using FA-ANN

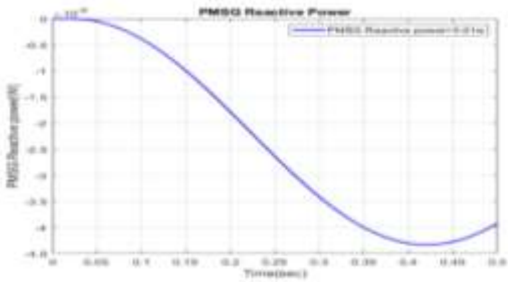


Figure 11. Active power and reactive power in the PMSG under normal wind speed condition using FA-ANN

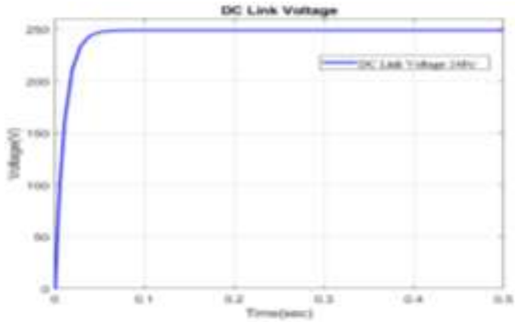


Figure 12. 4.4 DC-link voltage in normal wind speed condition using FAANN

When the sails are raised to their full height, the wind speed may be measured at 12 m/s; when the sails are lowered, the wind speed may be measured at 24 m/s. If the strategy is put into action, it will be possible to exercise control over wind speeds that are either lower than or comparable to the rated speed. The pitch angle control will help to smooth out the output power whenever the wind speed is greater than the cut-in speed of the PMSG.

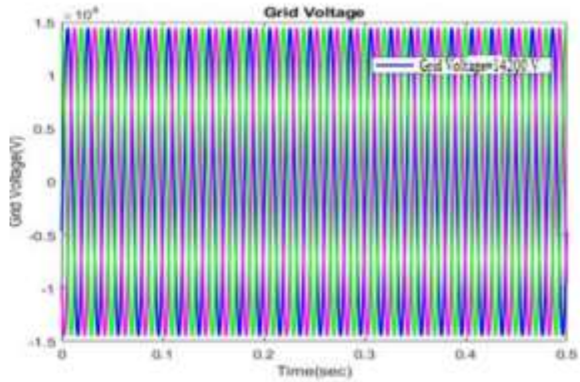


Figure 13. Three-phase voltage and current of grid in normal wind speed condition using FA-ANN

Figure 11 depicts the PMSG's active and reactive powers. At normal wind speeds, the PMSG's electrical speed is controlled by the optimum rational speed. At 0.5 seconds, the PMSG's active and reactive powers settle. As shown in Figure 12, the DC-link voltage output in a steady state is perfectly normal under these circumstances

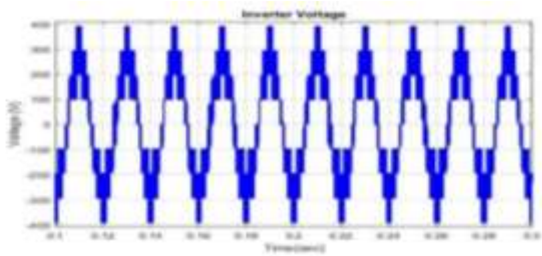


Figure 14 (a). Inverter voltage power in normal wind speed condition using FA-ANN

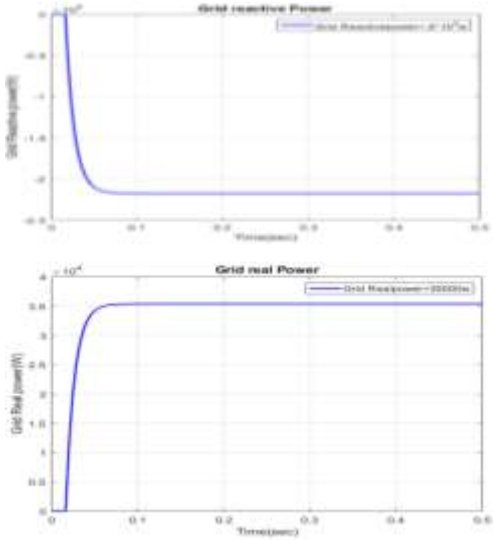


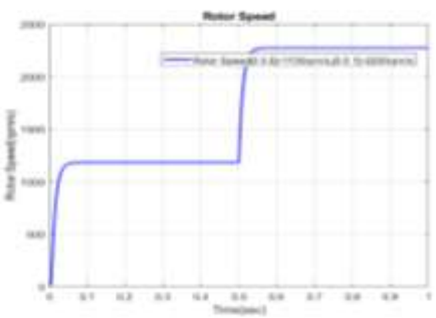
Figure 14(b) Grid real and reactive power in normal wind speed condition using FA-ANN

The settling time of 0.55 seconds and the corresponding voltage of 248V were used to determine the DC voltage. Figure 13 depicts the grid's three-phase voltage and current performance at normal conditions.

Figures 14 (a) and (b) depict various analyses, including those of the inverter voltage as well as the real and reactive power of the grid (b). By referring to this diagram, one can observe that the voltage that is present on the grid is kept at a stable level. As a result of its implementation, it has been demonstrated that the FA-ANN control technique is not only straightforward and reliable, but also enables greater adaptability and lessens the strain that is imposed on the blades of wind turbines. The vast majority of power fluctuations can be brought under control by utilising the FA-ANN method.

4.2 Analysis of variable wind speed

In this experiment, the voltages are analysed with the help of a motor that has a variable speed. Utilizing the proposed controller-based cascaded H-bridge MLI, we investigate the active power, reactive power, DC-link voltage, and harmonic compensation performance. The results of conducting tests on the proposed model in relation to different gust strengths are depicted in Figure 15.



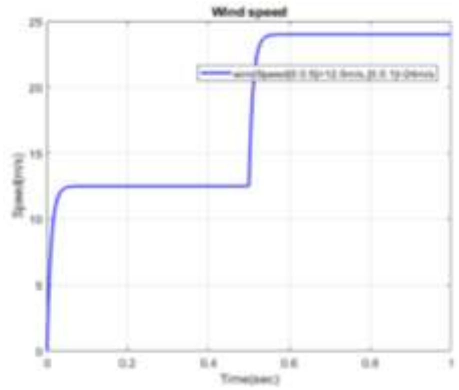


Figure 15. Rotor speed and wind speed in variable wind speed condition using FA-ANN

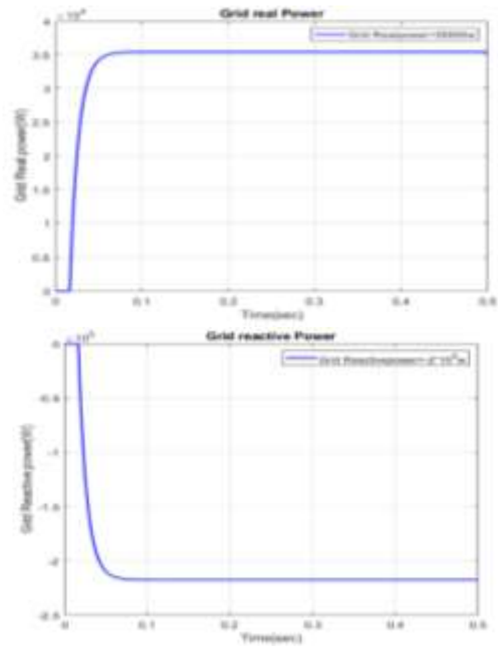


Figure 16. Active power and reactive power in the PMSG under variable wind speed condition using FA-ANN

The amount of power and voltage that is output by the wind generator is proportional to the speed of the wind (Figure 16). Because of the large fluctuations in output power that are brought on by the relatively minor shifts in wind speed, the required voltage fluctuation to ensure compliance with grid standards is increased.

4.3 Simulation Results

The following is the technical specification that the PMSG has developed for the FA-ANN method: The simulation is run in MATLAB with the help of the Implementation parameters, and the results are displayed here with the assistance of the Implementation parameters. Based on the Implementation parameters, the simulation is run in MATLAB, and the results are displayed here with the assistance of the Implementation parameters. Figure 4.9 illustrates the PMSG's real and reactive power performance, which was accomplished with the help of the suggested method. Voltages in the FA-DC-link ANN have been the subject of some research and analysis (Figure 17). It is clear that the time required for this DC-rise link is 0.001 seconds, the time required for its top-overshoot is 0.05" seconds, and the time required for it to reach steady state is 0.56" seconds (i.e., 200V settles in 0.56" seconds).

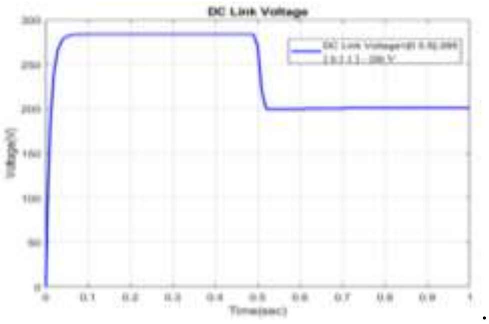


Figure 17. DC-link voltage in variable wind speed condition using FAANN

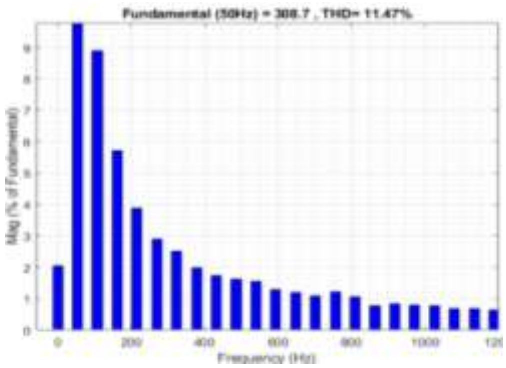


Figure 18. Voltage THD% analysis of FA-ANN method

The findings of a THD investigation into the suggested procedure are depicted in Figure 18.

The total harmonic distortion (THD) of the output of the grid-integrated power system control technique that has been proposed is 11.47 % a description of the factors at play Values Maximum wind speed of 12 meters per second speed of rotation at the point where it is slowest 1.2 (p.u) Power from the electrical source 605.142 watts (W).

Table 2 Comparison of voltage %THD of FA-ANN Proposed Method

	FA-ANN
THD%	11.81
Grid Voltage(V)	14200
Grid Current(A)	10
DC link Voltage(V)	247

Both the phase resistance of the stator, which is 0.18 ohm, and its inductance, which is 0.0167 H, are very low. Two poles to a pair Rigid-Rotary 4-Rotor The following equation describes the relationship that exists between the torque constant and the flux linkage: Its friction coefficient is 0.00030 F.N.ms, and its moment of inertia is 0.00062 J kgm.

5. CONCLUSION

The FA-ANN optimization method is simulated in the MATLAB/SIMULINK environment, and the output waveforms for a variety of conditions are analyzed. The control strategy of the WECS integrated grid is implemented in order to enhance the transient response of the power system. An adaptive FA-ANN technique is used to track real and reactive power in order to reduce the fluctuation in a steady state. This technique is based on the various speeds at which the wind is blowing. The PID controller organizer of the WECS integrated grid is responsible for managing the cascaded H-bridge multi-level inverters. This organizer also incorporates FA and ANN algorithms. A look was taken at the voltage of the system's DC link (Table 2). It is clear that the time required for this DC-rise link is 0.001 seconds, the time required for its top-overshoot is 0.05" seconds, and the time required for it to reach steady state is 0.56" seconds (i.e., 200V settles in 0.56" seconds). The FA-ANN control technique used by the grid-integrated power system has a total harmonic distortion of 11.47 %.

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