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"MAXIMUM POWER POINT TRACKING FOR WIND ENERGY SYSTEMS USING PETURB AND OBSERVE, INCREMENTAL CONDUCTANCE, CUCKOO SEARCH,FUZZY LOGIC CONTROL TECHNIQUES."

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Abstract: Nowadays, demands for the renewable energy resources are increasing significantly. The most popular ones are wind energy and solar energy resource. But the wind energy has a lower installation cost compared to the solar energy. Wind energy is one of the most prominent and developed renewable energy resources. A power electronic interface is needed in order to connect a Wind Energy Conversion System (WECS) to the load. The output power of wind Energy system varies depend on the wind speed. Due the nonlinear characteristic of the wind turbine, it is a challenging task to maintain the maximum power output of the wind Turbine for all wind speed conditions. This can be overcomed by implementing MPPT (Maximum Power Point Tracking). MPPT plays a crucial role in enhancing the efficiency and performance of WECS. Furthermore, recent advancements in MPPT algorithms, including perturb and observe (P&O), incremental conductance, Cuckoo Search and Fuzzy logic control (FLC), are discussed in detail. The abstract explains the insights into future research directions aimed at further enhancing the MPPT efficiency and reliability in wind energy systems, thus contributing to the sustainable development of renewable energy sources.

Index Term: Matlab, Wind energy conversion system,Peturb and Observe, Incremental conductance, Cuckoo search algorithm,Fuzzy logic control

I. INTRODUCTION

Energy has the great importance for our life and economy. The energy demand has greatly increased due to the industrial revolution. Fossil fuels have been started to be gradually depleted. The sustainability of our civilization is seriously threatened. On the other hand, the greenhouse gas emissions are still increasing due to the conventional generation of energy. It is a really global challenge to reduce carbon dioxide emissions and ensuring secure, clean and affordable energy, and to achieve more sustainable energy systems. Renewable energy is energy that comes from a source that won't run out. They are natural and self-replenishing, and usually have a low- or zero-carbon footprint. Burning fossil fuels to create electricity has long been a major contributor in the emission of greenhouse gases into our atmosphere, so these renewable sources are considered vital in the race to tackle climate change. Renewable energy, a pivotal force in our quest for sustainable development, harnesses the Earth's natural resources to generate power. From the inexhaustible rays of the sun to the ceaseless motion of wind and flowing waters, these sources not only offer an ecofriendly alternative but also pave the way for a resilient and cleaner energy future. This introduction marks the gateway to exploring the diverse realms of renewable energy and its transformative impact on our global energy landscape. Renewable energy sources are considered as a perfect option for generating clean and sustainable energy. There are many sources of renewable energy such as solar energy, wind energy, etc. Different types of renewable energy sources are: wind power, solar power, bioenergy (organic matter burned as a fuel) and hydroelectric, including tidal energy.

II LITERATURE REVIEW

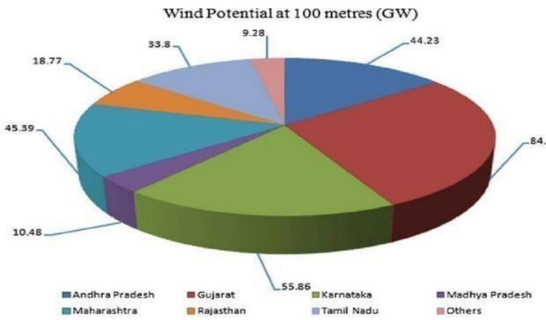
Maximum Power Point Tracking in wind energy systems has been a subject of extensive research. Various studies have explored different MPPT algorithms to enhance the efficiency of wind turbines. Perturb and Observe (P&O), Incremental Conductance (INC), and Fuzzy Logic Control are among the commonly investigated techniques.Researchers emphasize the importance of accurate wind speed prediction models integrated with MPPT algorithms for optimal energy extraction. The dynamic nature of wind necessitates adaptive algorithms that can swiftly respond to changes in wind conditions.

Studies also highlight the significance of MPPT in gridintegration, ensuring that wind energy systems operateat their maximum power output and contribute effectively tothe overall power generation. Moreover, advancements in control strategies, such as Model Predictive Control (MPC) and Artificial Neural Networks (ANNs), are gaining attention for their potential to further enhance MPPT performance.

Overall, the literature underscores the crucial role of MPPT in maximizing the energy capture from wind turbines, promoting sustainability in the renewable energy sector.

III DISCRIPTION OF SYSTEM (WIND ENERGY SYSTEM):

kinetic energy of air in motion into electricity. In modern wind turbines, wind rotates the rotor blades, which convert kinetic energy into rotational energy. This rotational energy is transferred by a shaft which to the generator, thereby producing electrical energy.Wind power has grown rapidly since 2000. It jumping from 7.5 GW in 1997 to some 733 GWby 2018 according to IRENA's data. Onshore wind capacity grew from 178 GW in 2010 to 699 GW in 2020, while offshore wind has grown proportionately more, but from a lower base,from



f i g : wind energy generation in various states across India

2020. Production of wind power increased by a factor of5.2 between 2009 and 2019 to reach 1412 TWh. Both onshore and offshore wind still have tremendous potential for greater deployment and improvement, globallyWind turbine capacity has increased over time. In 1985, typical turbines had a rated capacity of 0.05 MW and a rotor diameter of 15 metres. Today's new wind power projects have a turbinecapacity in 3-4 MW range onshore and 8-12 MW offshore.The amount of power that can be harvested from wind depends on the size of the turbine and the length of its blades. The output is proportional to the dimensions of the rotor and to the cube of the wind speed. Theoretically, when wind speed doubles, the wind power potential increases by a factor of eight.

BOOST CONVERTER:

Boost converters play a crucial role in MPPT for wind energy systems by efficiently regulating the power output of the wind turbine to match the load requirements.

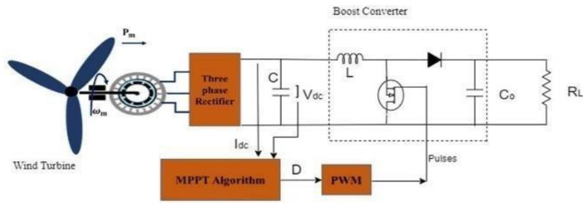


Fig: Block diagram of boost converter

the variable input voltage from the wind turbineinto a stable output voltage. This helps minimize power losses and enhances theoverall energy conversion efficiency of the system.In off-grid or hybrid wind energy systems, boost converters are used to charge batteries or energy storage systems. By regulating the voltage and current, boost converters ensure optimal charging of the batteries, thereby Wind turbines generate power over a wide range of wind speeds, leading tfluctuations in output voltage. Boost converters are employed to regulate the voltage output of the wind turbine to ensure compatibility with the downstream components or the grid. Boost converters enable MPPT controllers to adjust the operating point of the wind turbine to match the load requirements. By stepping up the voltage or current, boost converters ensure that the wind turbine operates at its maximum power point (MPP) under varying wind conditions, thus maximizing energy extraction.Boost converters improve the overall efficiency of the wind energy system by efficiently converting maximizing energy storage capacity and enhancing system reliabilityIn grid-connected wind energy systems, boost converters facilitatethe integration of wind power into the electrical grid by adjusting the power output of the wind turbine to meet grid requirements. This includes maintaining power quality, voltage stability, and frequency regulation. Overall, boost converters play a vital role in MPPT for wind energy systems by optimizing power extraction from the wind turbine and ensuring efficient operation under varying environmental conditions. Their flexibility and versatility make them indispensable components in modern wind energy conversion systems.

PERTURB AND OBSERVE METHOD:

In this method the controller adjusts the voltage from the array by a small amount and measures power; if the power increases, further adjustments in that direction are tried until power no longer increases. This is called perturb and observe (P&O) and is most common, although this method can cause power output to oscillate. It is also referred to as a hill climbing method, because it depends on the rise of the curve of power against voltage below the maximum power point, and the fall above that point. Perturb and observe is the most commonly used method due to its ease of implementation. Perturb and observe method may result in top-level efficiency, provided that a proper predictive and adaptive hill climbing strategy is adopted. the P&O MPPT method. As the name says, the algorithm is based on the observation of the wind turbine output power and on the perturbation of the power based on increments of the wind turbine voltage or current. The algorithm continuously increments or decrements the reference current or voltage based on the value of the previous power sample.The P&O method claimed to have slow dynamic response and high steady state error. In fact, the dynamic response is low when a small increment value and a low sampling rate are employed. Low increments are necessary to decrease the steady state error because the P&O always makes the operating point oscillate near the MPP, but never at the MPP exactly. The lower the increment, the closer the system will be to the array MPP. The greater the increment, the faster the algorithm will work, but the steady state error will be increased. Considering that a low increment is necessary a satisfactory steady state error, the algorithm speed may be increased with a higher sampling rate Overall, the P&O algorithm provides a simple and effective way to track the MPP of a wind turbine in real-time, maximizing the energy harvesting efficiency under varying wind conditions. However, it may exhibit some drawbacks such as oscillations around the MPP and slower response times compared to more advanced MPPT algorithms.

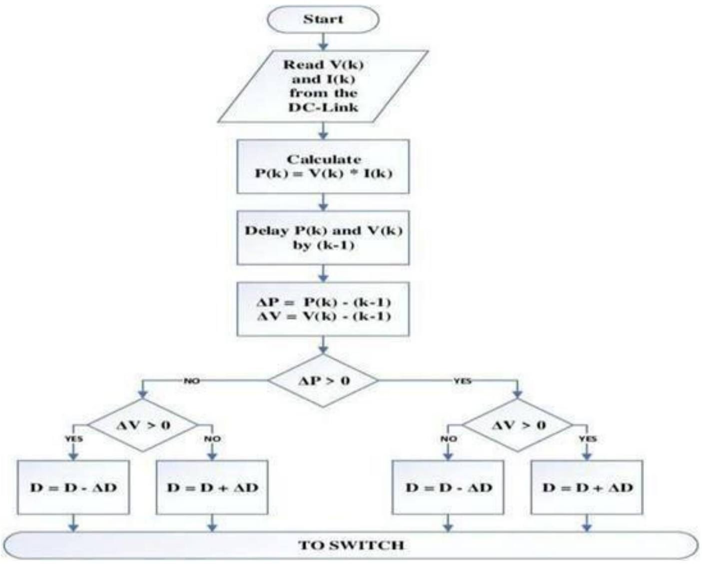


Fig: flow chart of perturb and observe algorithm

the simulation diagram of the P & O method. As we know the wind turbine will be varying with respect to temperature and wind conditions. The input power at PMSG is 5.905KW and the obtained output/Boost-Converter power is 4.316KW.The Boost-Converter is used to step the output voltage, current, power. And the code for P&O Algorithm is written in the P&O block. The output voltage, current and power wave forms of P&O algorithm is shown in the above Figure.2.3 It indicates that the output voltage, current and power of wind turbine are varying with respect to time in seconds.

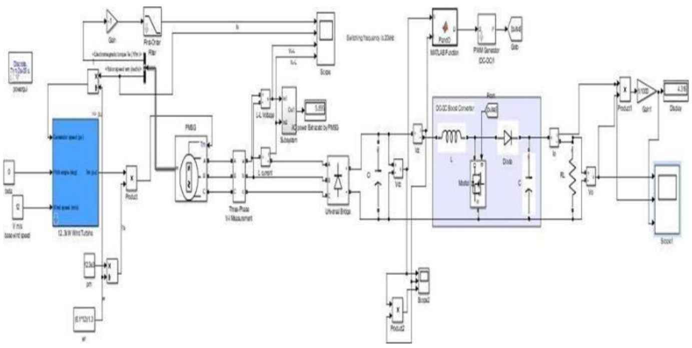


Fig: simulation of mppt using p&o method

The input voltage applied to the PMSG has more fluctuations shown in figure 2.3 and the voltage level is 100 V, but the output voltage/load voltage has less fluctuations and voltage has raised to 250V shown in figure 2.4.The results of P &O MPPT for wind energy typically involve achieving efficiency and improved power tracking under varying wind conditions. The P&O method does not track exact maximum power point and has some limitations. So, to get better performance of tracking maximum power from wind turbine the next MPPT technique Incremental conductance method is employed.P&O method. From the algorithm it has been concluded that the P&O method does not track exact maximum power point and has some limitations. So, to get better performance of tracking maximum power from wind turbine the next MPPT technique Incremental conductance method is employed.

The detailed analysis is discussed in the next chapter.

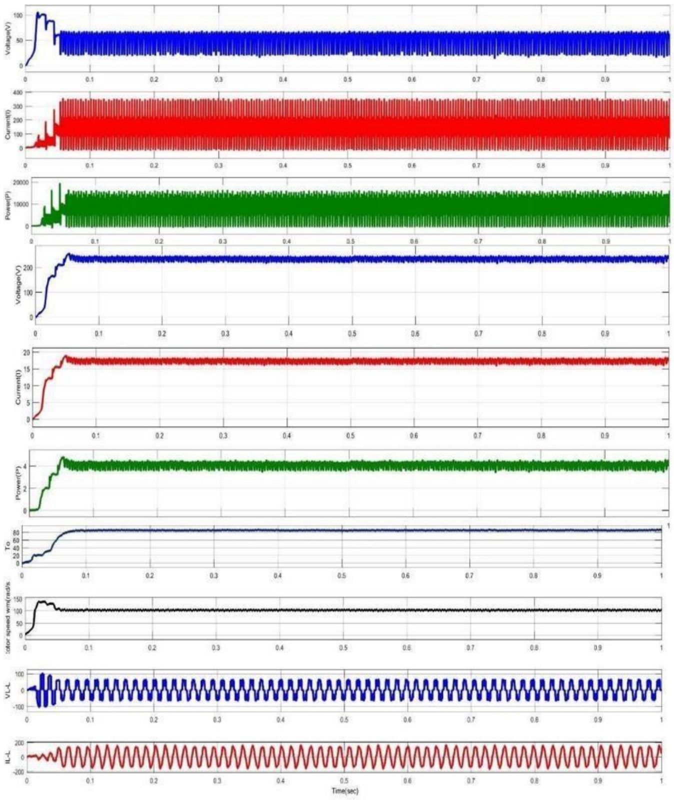


Fig: output curves of p&o method

INCREMENTAL CONDUCTANCE:

Incremental Conductance (INC) is a popular algorithm used in Maximum Power Point Tracking (MPPT) systems for wind energy generation. It's designed to continuously track andadjust the operating point of the wind turbine to ensure it operates at its maximum power output,even as environmental conditions change. The incremental conductance algorithm works by comparing the instantaneous change in power with the change in wind speed, adjusting the turbine's operating point accordingly to maximize power extraction. This dynamic adjustmenthelps to optimize the efficiency of wind energy conversion systems.Incremental Conductance algorithm is one of the most widely used techniques for MPPT in various renewable energy systems, including solar and wind. It works by continuously comparing the incremental change in power (dP) with the incremental change in voltage (dV) and adjusting the operating point accordingly to track the maximum power point (MPP).Among the various MPPT algorithms, the Incremental Conductance algorithm has gained prominence for its effectiveness and adaptability. The Incremental Conductance algorithm hasbeen successfully adapted for wind energy applications.the block diagram of the Incremental conductance MPPT method. The Incremental Conductance method works by continuously monitoring the instantaneous output power and the change in output power with respect to changes in the operating voltage and current. When the change in power reaches zero, the operating point of the wind energy system is at the maximum power point.This method involves observation of the rectifier output power, which is used for tracking the MPP and deciding the perturbation direction. The need for sensors and the knowledge of the WT parameters is eliminated by using the INC algorithm, which results in the increased reliability and efficiency. The changes in the

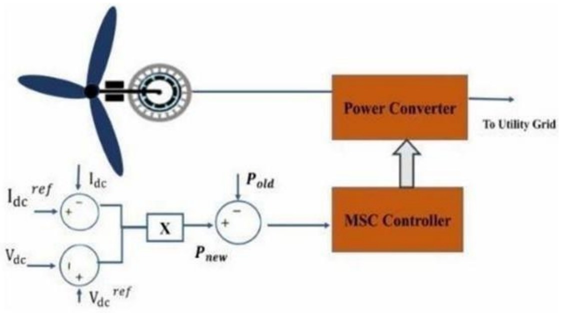


Fig: Block diagram of INC Algorithm

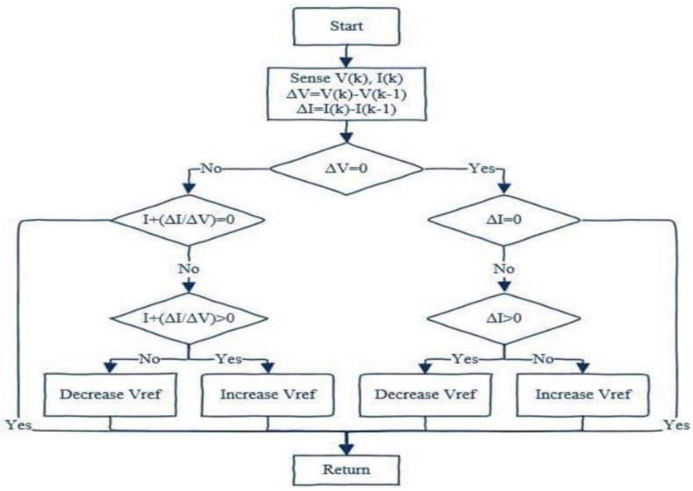


Fig: flow chart of INC Algorithm

The Boost-Converter is used to step the output voltage, current, power. And the code for IC Algorithm is written in the IC block. The output voltage, current and power waveforms of IC algorithm is shown in the above Fig.3.4. It indicates that the output voltage, current and powerof wind turbine are varying with respect to time in seconds.The figure 3.3 shows the simulation diagram of IC method. As we know the wind turbine willbe varying with respect to temperature and wind conditions. The input power at PMSG is **5.905KW** and the obtained output/Boost-Converter power is **4.307KW**.

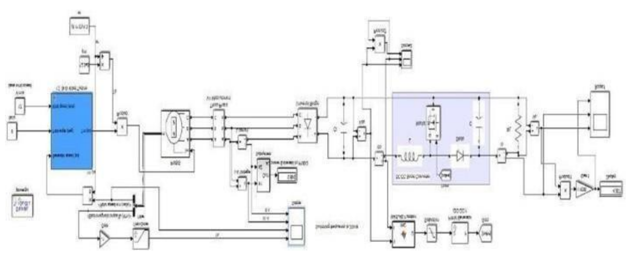


Fig: simulation of mppt using INC method

CUCKOO SEARCH METHOD

The Cuckoo Search Algorithm (CSA) is a metaheuristic optimization technique inspired by the behaviour of cuckoo birds. These birds lay their eggs in the nests of other host birds. If the hostbird detects these foreign eggs, it either discards them or abandons the nest to build a new one.In CSA, each egg in a nest represents a solution to an optimization problem [20]. The cuckoo eggs symbolize new and potentially better options based on existing solutions.Metaheuristics are generic optimization methods that seek promising solutions across various problems unlike problem-specific heuristics, metaheuristics follow a problem-independent design principle and are designed for global optimization.By balancing the exploration and exploitation, the Cuckoo Search Algorithm [22] can efficiently solve optimization problems. The Cuckoo Search Algorithm has been successfully applied to various optimization problems, such as function optimization, engineering design, and machine learning. It offers advantages like simplicity, flexibility, and good convergence properties.The main idea behind the Cuckoo Search Algorithm is to generate new solutions by combining the existing ones and replacing the worst solutions with the newly generated ones. This processis repeated until a satisfactory solution is found. The algorithm also incorporates a random walkmechanism to explore the search space effectively.It's used in various optimization problems, including Maximum Power Point Tracking (MPPT)for wind energy systems. In the context of MPPT, Cuckoo Search can be employed to find the optimal operating point of a wind turbine to maximize power output. By iteratively adjusting parameters such as rotor speed or blade pitch angle, the algorithm seeks to converge to the point where the wind turbine operates at its maximum power output under varying windconditions. This optimization can enhance the overall efficiency and performance of wind energy systems.

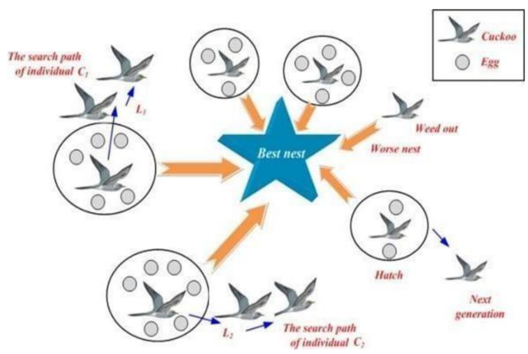


Fig:cuckoo search method

Cuckoo search, which drew its inspiration from the brooding parasitism of cuckoo species in Nature, were firstly proposed as a tool for numerical function optimization and continuous problem. Since then, the original developers of this algorithm and many researchers have alsoapplied this algorithm to engineering optimization, where Cuckoo search also showed promising results. Nowadays cuckoo search has been

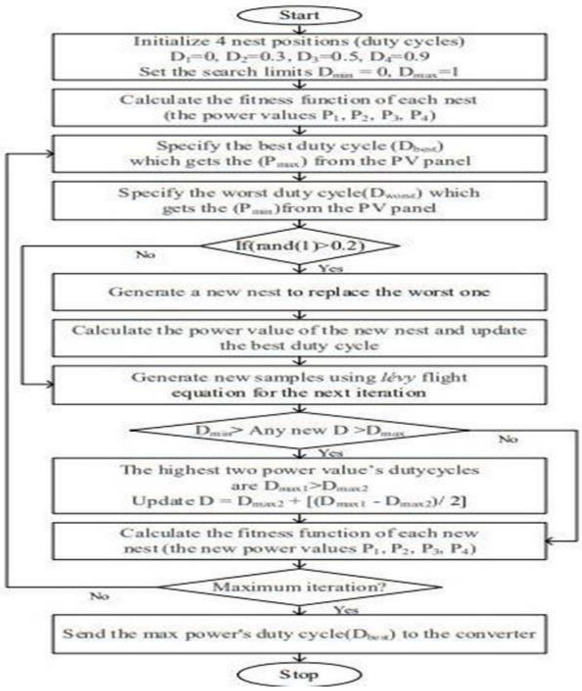


Fig:flow chart of cuckoo search algorithm

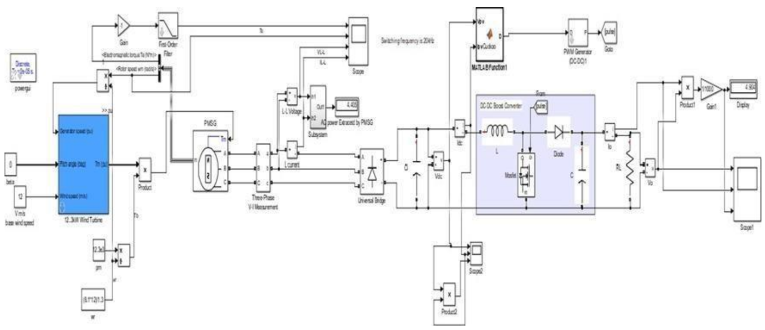


Fig:Simulink mppt using cuckoo method

The Boost-Converter is used to step the output voltage, current, power. And the code for CSAAlgorithm is written in the IC block. The output voltage, current and power waveforms of IC algorithm is shown in the above Fig.4.4. It indicates that the output voltage, current and powerof wind turbine are varying with respect to time in seconds. The figure 4.3 shows the simulationdiagram of CSA method. As we know the wind turbine will be varying with respect to temperature and wind conditions. The input power at PMSG is **5.905KW** and the obtained output/Boost-Converter power is **4.904KW.**

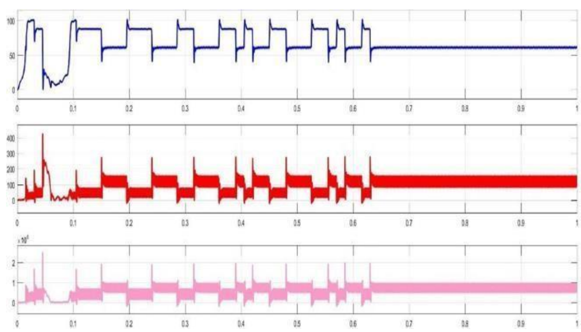
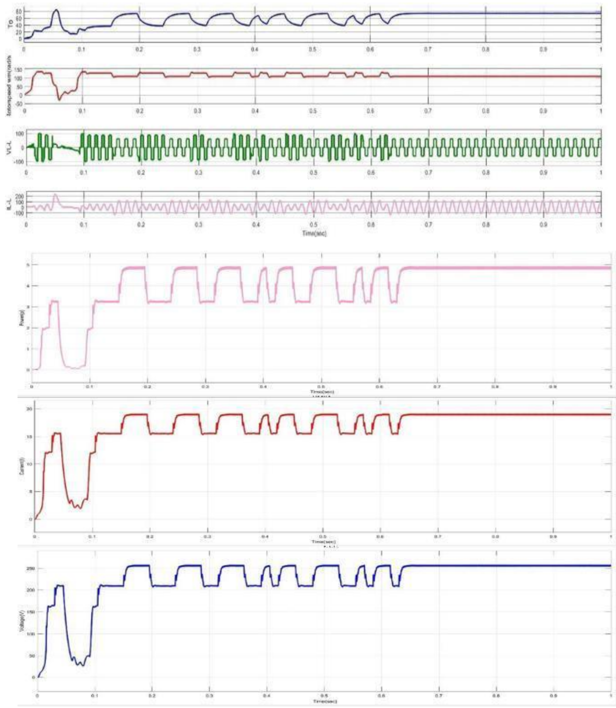


Fig: power output of cuckoo method

P&O algorithm, INC algorithm are the best and easy



methods but provides more oscillations at output and less performance, low efficiency to overcome these drawbacks using Cuckoo optimization technique.This Chapter explained MPPT with Cuckoo optimization algorithm which has less oscillationsat output, stable voltage and more efficient when compared to P&O, INC algorithm.

MPPT WITH FUZZY LOGIC CONTROL:

Maximum Power Point Tracking (MPPT) is a technique used in renewable energy systems, including wind energy, to optimize power generation. Fuzzy logic control[4] is a method that allows systems to make decisions based on imprecise or uncertain data. When combined, fuzzy logic control[4] can enhance MPPT algorithms by adapting to changing environmental conditions and system parameters more effectively than traditional methods. In wind energy systems, this integration can lead to increased energy capture and improved overall performance.

Fuzzy logic provides a means to make decisions based on imprecise or uncertain input data.In the context of MPPT for wind energy, fuzzy logic can adaptively adjust turbine parameters such as blade pitch angle or generator torque based on fuzzy rules that consider factors like wind speed, turbine speed, and power output.Fuzzy logic control of Maximum Power Point Tracking (MPPT) in wind energy systems involves using fuzzy logic algorithms to dynamically adjust turbine parameters in order to optimize power generation in varying wind conditions.By integrating fuzzy logic control into MPPT algorithms, wind energy systems can achieve improved energy capture efficiency and smoother operation across a wide range of wind conditions. This adaptive approach enables turbines to continuously track and respond to change in the wind, maximizing power generation and overall system performance.

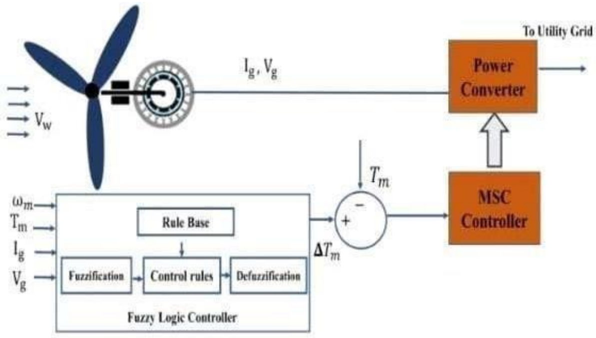


Fig: Block diagram FLC Algorithm

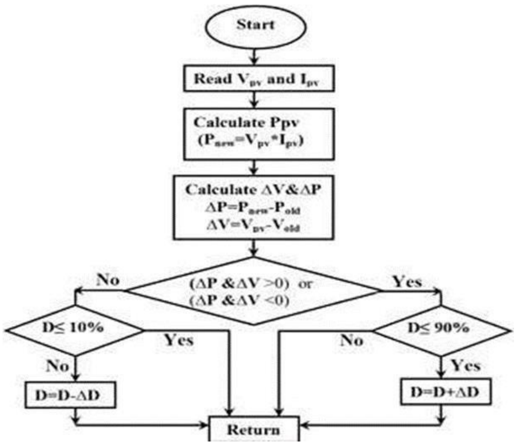


Fig: Flow chart of FLC

By integrating fuzzy logic control into MPPT algorithms, wind energy systems can achieve improved energy capture efficiency and smoother operation across a wide range of windconditions. This adaptive approach enables turbines to continuously track and respond to changes in the wind, maximizing power generation and overall system performance.

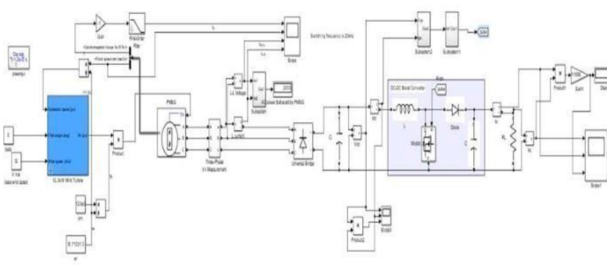
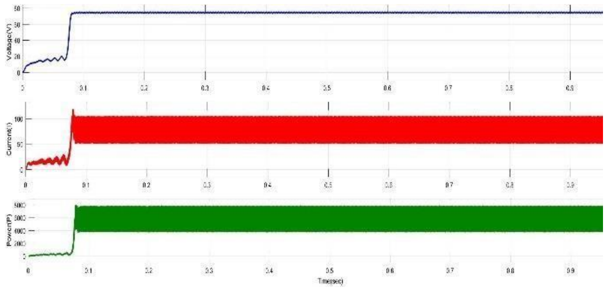
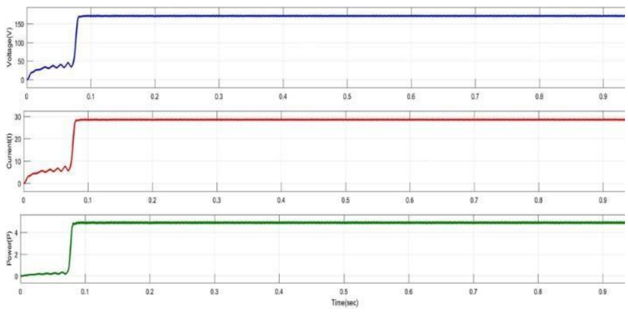


FIG: Simulink/MATLAB model of MPPT with FLC algorithm

CSA algorithm the fluctuations are less in FLC Algorithm shown in fig 3.6. This method allows wind turbines to dynamically adjust their rotor speed or blade pitch to maintain optimal power output as wind speed fluctuates. By continuously monitoring changes in wind speed and adjusting turbine parameters accordingly, Fuzzy Logic Control of MPPT helps maximize energy capture and enhance overall system performance.





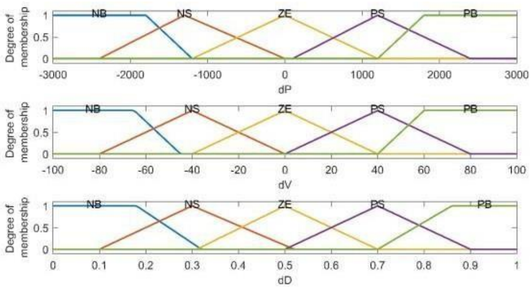


Fig: power outout of using FLC method

COMPARITIVE ANALYSIS

A comparative study is performed with IC, P&O, CSA and FLC methods. The comparisons shows that with same irradiance values the area under the curve in the power plot is more in FLC than P&O and IC, CSA algorithms but more power is generated using CSA algorithm than IC and P&O algorithm. In FLC algorithm and CSA algorithm voltage curve settles down fast than, P&O and IC algorithms. So, FLC and CSA algorithm leads to less settling time. This study proves that Perturb and observe, Incremental conductance, Cuckoo Search, Fuzzy logic should have very similar overall efficiencies, but that Fuzzy Logic, Cuckoo Search should be slightly better. However, the results of this study indicate that, to within accuracy available the MPPT efficiencies of P&O, IC, CSA, FLC are essentially same.Furthermore P&O, IC had the same performance underclear sky conditions, indicating that the penalty in efficiencycaused by the oscillation about MPP inherent in P&O under steady-state conditions was insignificant for the optimized algorithms. Cuckoo search outperformed IC, P&O under partly cloudy conditions, as expected but the difference was very small. Also interestingly, FLC had a significantly higher efficiency than Cuckoo search. Simulation works confirm thebest performance of fuzzy logic control MPPT algorithm to achieve low oscillation and overshoot, which contributes to highly stability operation.

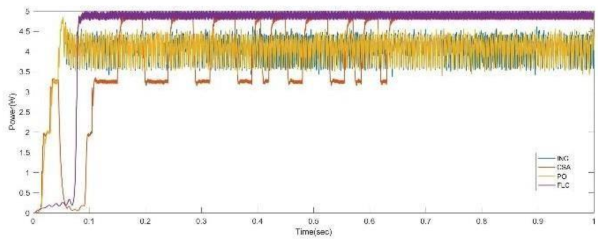


Fig: Comparision between of p&o ,increment conductance, cuckoo search method ,FLC method

REFERENCES:

1. Buehring, I.K., Freris, L.L.: ‘Control policies for wind-energy conversion systems. Proc. IEEE Conf. of Generation, Transmission and Distribution, 1981, pp. 253–261.
2. Iyasere, E., Salah, M., Dawson, D., et al.: ‘Optimum seeking-based non-linear controller tomaximise energy capture in a variable speed wind turbine’, IET Control Theory Appl., 2012, 06, (04), pp. 526–532.
3. Vepa, R.: ‘Nonlinear, optimal control of a wind turbine generator’, IEEE Energy Convers., 2011, 26, (02), pp. 468–478.
4. Chen, Y., Pillay, P., Khan, A.: ‘PM wind generator topologies’, IEEE Ind. Appl., 2005, 41, (06), pp. 1619–1626.
5. Mahesh, P. Venkata, S. Meyyappan, and Rama Koteswara Rao Alla. "A new multivariate linear regression MPPT algorithm for solar PV system with boost converter." ECTI Transactions on Electrical Engineering, Electronics, and Communications 20.2 (2022): 269-281.
6. Mahesh, P. Venkata, S. Meyyappan, and RamaKoteswara Rao Alla. "Maximum power point tracking using decision-tree machine-learning algorithm for photovoltaic systems." Clean Energy 6.5 (2022): 762-775.
7. Mahesh, P. Venkata, S. Meyyappan, and R. Alla. "Maximum power point tracking with regression machine learning algorithms for solar PV systems." International Journal of Renewable Energy Research 12.3 (2022): 1327-1338
8. Mahesh, P. Venkata, S. Meyyappan, and RamaKoteswaraRao Alla. "Support Vector Regression Machine Learning based Maximum Power Point Tracking for Solar Photovoltaic systems." International journal of electrical and computer engineering systems 14.1 (2023): 100-108
9. Serban, I., Marinescu, C.: ‘A sensorless control method for variable-speed small wind turbines’, Elsevier Renew. Energy, 2012, 43, pp. 256–266.
10. Vijay Chand Ganti, Bhim Singh, Shiv Kumar Aggarwal, and Tara Chandra Kandpal (2012). “DFIG-Based Wind Power Conversion with Grid Power Leveling for Reduced Gusts”, IEEE Transactions on Sustainable Energy, Vol. 3(1), pp.12-20. https://doi.org/10.1109/TSTE.2011.2170