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WIND ENERGY CONVERSION SYSTEMS BY MAXIMUM POWER TRACKING CONTROL TECHNIQUE

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ABSTRACT

In this, a MPPT control technique is introduced for a variable speed, grid connected direct driven PMSG wind turbine. The PMSG is connected to the grid through three-phase diode rectifier followed by a boost converter controlled with the MPPT technique to maintain a constant DC bus voltage for different wind velocities and extracting the maximum available power with the change in wind speed. The grid-side inverter then generates a voltage whose fundamental component has the grid frequency, and also being able to supply the active nominal power to the grid. Different power converter topologies and MPPT techniques used for variable speed wind turbine systems are reviewed. The presented sensor less system, estimates the rotor speed depending on some known generator parameters and measuring the input dc voltage and current for the boost converter. The main challenge was to adapt and modify this MPPT technique to work with high efficiency on large scale wind turbine system. The system performance is investigated using MATLAB/SIMULINKfor a 2MWwind turbine system. If the generator is run at the optimum speed for the wind Speed, a system for converting wind energy (WECS) power output efficiency can be maximized. Using a Maximum Power Point Tracking (MPPT) controller will result in the best operating point. MPPT's control, however, is made challenging by the fluctuating wind speed. The optimal operating point can be determined using adaptive control techniques, which are discussed in this study along with a proposal for MPPT control based on APO approaches. Numerical simulations are used to validate the WECSs' performances when applying the proposed adaptive control strategies. These performances are compared to those produced by utilizing a CPO controller (conventional perturbation and observation), and the suggested APO for MPPT control, control strategies result in greater performance.

Keywords- Permanent Magnet Synchronous Generator (PMSG), Wind Energy Conversion System (WECS), Maximum Power Point Tracking (MPPT), The terms "wind turbine," "conventional interference and disturbance," and "adaptive interference and disturbance" are all used.

1. INTRODUCTION

Currently, Across the world, renewable energy projects are being developed as the main energy sources. A system for converting wind energy (WECS) under consideration is consisting of a Permanent Magnet Synchronous Generator connected to a Little Wind Turbine with Variable Speed (PMSG). Figure 1 shows the WECS block architecture, which uses controllers for both the generator and grid side converters.

The windmill with variable speed and fixed pitch must have the Maximum Power Point Tracking (MPPT) facility to operate at its best finding and following the literature provides information on the maximum power point using a variety of methodologies, including Traditional Perturbation, Control of the Power Signal Feedback (PSF) Observation(CPO) To acquire the ideal the speed of a wind turbine for each wind speed, the CPO reliable, strong, and simple technique of modifying the generator speed. To ensure maximum power, this technique only slightly modifies the rotor speed, and it continuously tracks variations untill it achieves 0.0, or zero, output power. We developed and applied adaptive MPPT control techniques known as adaptive interference and disturbance (APO) approach enhance the MPPT

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properties in WECS's in this study.

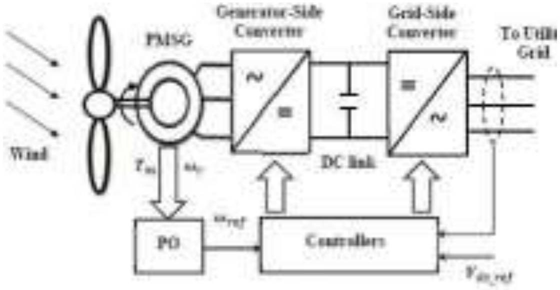

Fig. 1. Block diagram of a WECS

I.WINDENERGY CONVERSION SYSTEM

The fixed pitch wind turbine, PMSG, converters, and controls that make up the WECS are seen in Fig. 1. Typically, a rectifier (generator side converter) The generated electrical power first needs to be converted to a DC one It must then be transformed via grid-side converter to AC electricity with regulated current (inverter stage) before being injected into the utility grid. Wind kinetic energy from wind turbines is used to drive the PMSG shaft mechanically. As a result, the mechanical power generated is converted into electrical energy by the PMSG. One approach to represent the power produced by wind is as the wind's velocity in a turbine blade (kinetic energy). a cross- adorned cylinder the location of the rotor blade's radius sectional area equals 2, where. Thus, the shape of the wind energy produced is as follows.

$$P_w = 0.5\rho A V_w^3 \quad (1)$$

When the air density is given by. Usually speaking, wind turbines are made to functioning a certain range of wind speeds. when the wind speed is lower than the rated wind speed for the turbine-its mechanical power increases cubically with wind speed in terms of value, as demonstrated by

$$P_m = C_p P_w = \frac{1}{2}\rho\, C_p A\, V_w^3 \quad (2)$$

Hence, and are ratio between tip speed and pitch angle, respectively, which functionallydepend on the efficiency of power conversion.

You can define the tip speed ratio as follows [2]:

$$\lambda = \omega_r R_r / V_w \quad (3)$$

$$C_p(\lambda, \theta) = 0.5\left(116\frac{1}{\lambda_i} - 0.4\theta - 5\right)e^{-\left(\frac{21}{\lambda_i}\right)} + 0.0068\lambda_i \quad (4)$$

where, ω_r is the rotor speed. Hence, λ_i can be obtained as follows:

$$1/\lambda_i = 1/(\lambda + 0.08\,\theta) - 0.035/(1 + \theta^3) \quad (5)$$

When keeping the pitch angle θ at zero degree, C_p will be a function of λ only as shown below [19]:

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$$C_p(\lambda) = \left(\frac{60.04-4.67\lambda}{\lambda}\right) e^{\left(\frac{-21+0.735\lambda}{\lambda}\right)} + \frac{0.0068\,\lambda}{1-0.035\lambda}$$

The highest power coefficient value Cp opt in theory is roughly 0.59, although in practise, Cp opt can have a value that is less than 0.59. Cp_opt, for instance, has theoretical value of 0.48. According to this number is obtained at an optimal tip speed ratio of =8.1, per [2,] which demonstrates the connection between two wind turbine parameters Cp and λ .

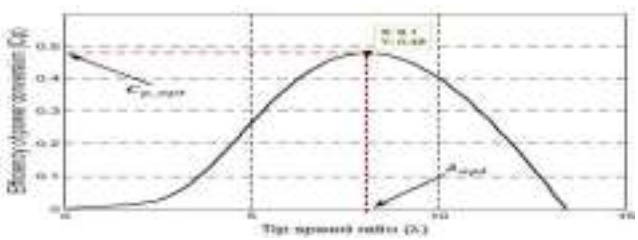

Fig. 2. Power coefficient characteristic versus tip speed ratio

Winds up to 12 m/s have their strongest point. should be tracked by a WECS through the control system to ensure that it operates as efficiently as possible. technique that should maintain these circumstances throughout the process, regardless of changes in speed.

2 . LITERATURE SURVEY

The literature reports on a number of MPPT strategies and how they were put into practise. While choosing an MPPT technique for a certain application, researchers are almost always perplexed. Curve fitting, fractional short circuit current, fractional open circuit voltage, look up tables, and one cycle were among the few techniques that were unfortunately available in this subject. Before 2007, comments on MPPT approaches were included under the Control, Perturb and Observe, Incremental Conductance, and Feedback techniques. However, numerous new MPPT methods, including those based on fuzzy logic, artificial neural networks, adaptive perturbation and observation, estimated perturbation and perturbation, genetic algorithms, adaptive neuro fuzzy, and particles warm optimization, have been reported and demonstrated since then. A review of all the
efficient and effective MPPT methods proposed before 2007 and after that up until 2013must be prepared. A review and comparison of MPPT approaches based on their benefits, drawbacks, the presence of control variables, the types of circuits used, the difficulty of the algorithm, the difficulty of implementing it on hardware, and the kinds of scientific and It describes a commercial application. Perturb & Observe (P&O) and Incremental Conductance (IC) are the two MPPT approaches that are most frequently utilized due to their ease of implementation, the short time required to track the maximum power point, as well as other economic factors. P&O interprets a continuous change in MPP caused by unexpectedly changing weather circumstances (irradiation level) as a change in MPPT caused by disturbance rather than irradiation. results in the erroneous MPPT being calculated [6]. Nevertheless, the Incremental Conductance approach eliminates this issue because it uses two samples of voltage and current to calculate MPPT. The most popular MPPT techniques are Perturb & Observe (P&O) and Incremental Conductance because they are easy to apply, take less time to track the maximum power point, and are also more practical from an economic standpoint. As MPPT fluctuates continuously in response to abrupt changes in the weather (irradiation level), P&O interprets this as an MPPT change owing to disturbance rather than irradiation and occasionally results in the calculation of the incorrect MPPT[7]. Nevertheless, the Incremental Conductance technique does not haven this issue because it computes MPPT using two samples of voltage and current.

3 . PROPOSED SYSTEM

There is only one rotational speed that can operate a wind turbine at its highest power point for each wind speed within its operating range mechanical power at its highest level. The Conventional Perturbation and Observation (CPO) optimization technique is often used in WECS control to discover the optimal operating point that would maximize the power extracted from a system. In this study, step-size Adaptive Perturbation and Perturbation(APO)techniques are created to improve the

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effectiveness and precision of the CPOmethodology.

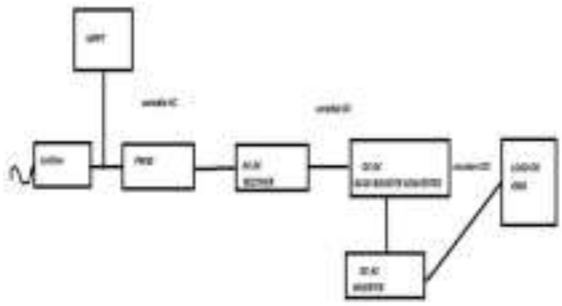

Fig. 3:Block diagram

According to the literature, using a fixed step-size speed causes variations in the MPPT reference speed to be seen [15–17]. When the speed step-size is increased, these variations will get worse. Yet, as is decreased, the settling period will lengthen while the fluctuations are reduced. According on the operating point, the proposed APO approaches offer a modified The rotor speed is divided into steps. The following general idea has been suggested for control rules to accomplish swift and accurate aiming for the ideal operation: To enable quick response for a low power along the power curve, adjusted with large values, the step-size will be lower on the one hand.

These values ought to be raised progressively until they are close to the optimal operating point. On the other hand, the step-size will be set with The ideal operating point should be reached high power on the power curve at minute values, and these values ought to steadily decreased until nearing zero. This will ensure an accurate MPPT answer. A step-size of the speed is also modified based on the variation of mechanical power with i.e. $dP_m/d\omega_r$ regard to rotor-speed .

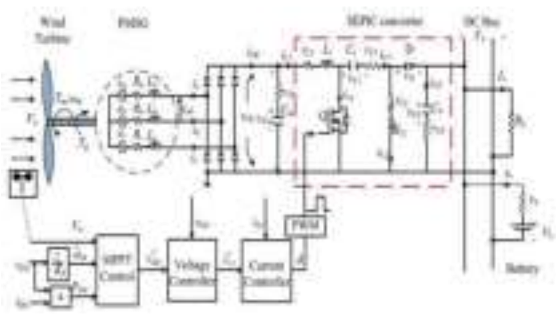

Fig .4:WECS configuration

The i.e. $dP_m/d\omega_r$ curve of can be separated into three areas, as shown in Fig. 3. As both of i.e. $dP_m/d\omega_r$ and the first area can be referred to as the first Accelerated Speed Region (ASR I), (Second derivative of the power) has positive values, as does. The second zone, where has a positive value and has a negative value, is known as the Decelerated Speed Region (DSR). The third zone is referred to as the second Accelerated Speed Region II (ASR II), when both and have negative values. It is evident from Fig. 3 that the feature of the above-mentioned proposed control rules is present when step-size is used as a function of i.e. In order to expedite the ASR I, an incremental value of can be provided where the value of continuously declines near the optimal position during DSR or ASR II until it approaches zero for tracking the ideal operatingpoint with precision.

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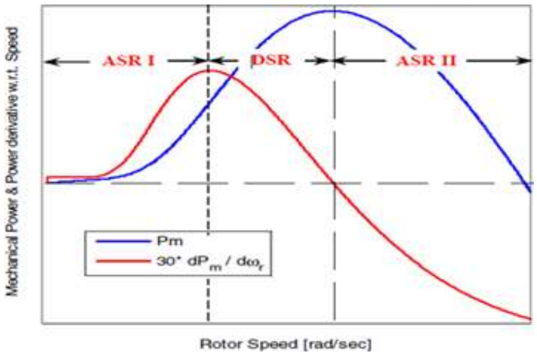

Fig. 5. Mechanical energy, together with its derivatives, respect to rotor speed.

It should also be noticed that the value of is dependent the wind's value, as shown in Fig. 4, where it is depicted as a solid lines and is represented by dashed lines. The various colours in the figure indicate that those curves were obtained for varied wind speed values (blue for high wind speed, green for moderate wind speed and intermediate-level red colour. In other words, for the same speed area and Considering numbers that account for various wind speeds are proportionate to the wind speed values.

As a result, the suggested control rules often accelerate the search for the optimum operating point and reduce variations that can occur when using the CPO
technique. As previously stated, the derivation of mechanical power with regard to rotor speed is employed to determine the speed step-size. Two potential applications have been suggested. A study provides adaptive, in which the first has been treated as a direct proportion of and is represented the following (7) Identify a variable parameter.

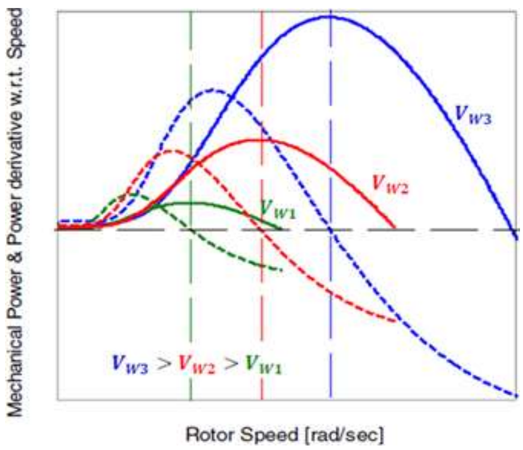

Fig.6.For various wind speeds, mechanical power and its derivatives with regard to rotor speed.

4. RESULTS AND DISCUSSION

Back-to-back interface-based WECS and PMSG numerical simulations were conducted to highlight and assess the efficacy of the suggested APO control mechanisms. The MATLAB / Simulink programme was used to perform conversions. During the regular change in wind speed, the values of and λ remain at their optimum values, despite the variation in the wind and rotor speeds indicating good tracking performance of the WECS. However, in case of rapid change of the wind speed, all cases fail to obtain optimum tracking of the operating points. It can therefore be concluded from the results of simulation that the proposed control algorithm has good capability of tracking peak power points. The method also has good application potential in other types of WECS.

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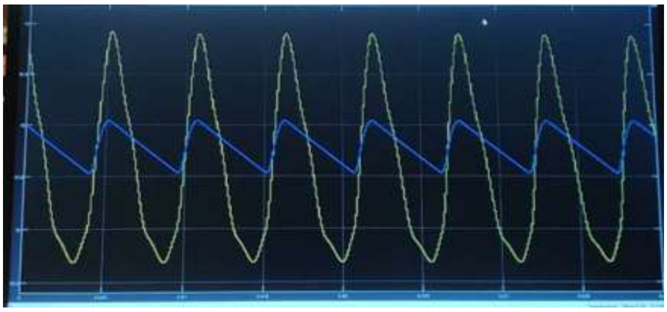

Fig.6. Reference wind speed obtained by APO technique

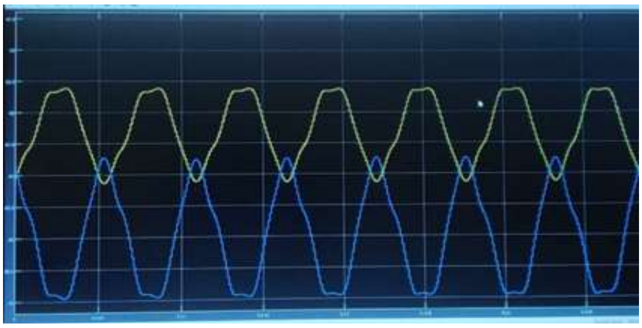

Fig .7.Generated maximum speed(blue solid line)and rotor speed.

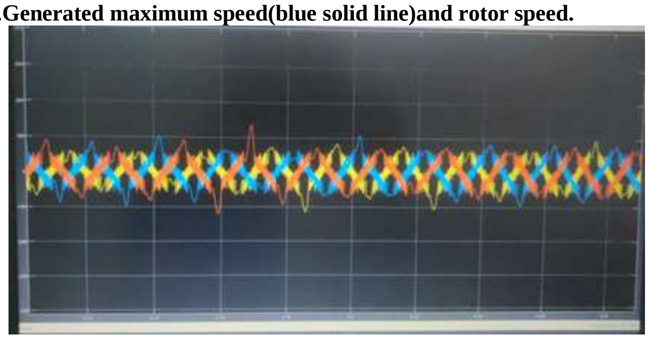

Fig.8. Mechanical power obtained by APO technique with respect to rotor speed

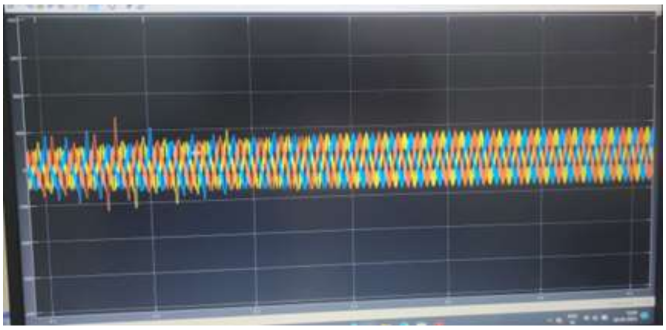

Fig.9. Maximum voltage

5. CONCLUSION

Wind energy conversion system has been receiving widest attention among the various renewable energy systems. Extraction of maximum possible power from the available wind power has been an important research area among which wind speed sensor less MPPT control has been a very active area of research. In this chapter, a concise review of MPPT control methods proposed in various literature's for controlling WECS with various generators have been presented. The optimal operation of WECS has been proposed in this paper using APO techniques. By using computer models to test the suggested control mechanisms for variations in wind speed, their effectiveness has been proven. The proposed APO controllers have been implemented, and simulation results support their ability to increase the MPPT performance's accuracy and efficiency There is a continuing effort to make converter and control schemes more efficient and cost effective in hopes of developing an economically viable solution to increasing environmental issues. Wind power generation has grown at an alarming rate in the past decade and will continue to do so as power electronic technology continues to advance.

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