e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:05/Issue:10/October-2023 Impact Factor- 7.868 www.irjmets.com

AN OVERVIEW OF MPPT TECHNIQUES IN WIND ENERGY CONVERSION SYSTEM

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DOI : https://www.doi.org/10.56726/IRJMETS45160

ABSTRACT

Renewable energy resources are alternative approach of fossil fuel resources, which are being continuously available throughout the year. Wind is one of the major fastest growing renewable energy resource which produces large amount of energy. Although wind energy is easily available, the speed of wind is not constant throughout the time. It depends on the region. So, several techniques have been discussed to harness maximum power from wind energy. This paper presents about four types of maximum power point techniques (MPPT) like Optimal torque (OT), Tip Speed Ratio (TSR), Perturb and Observe (P&O) and Fuzzy Logic Control (FLC) used in wind energy conversion system.

Keywords: MPPT, WECS, OT, Speed.

I. INTRODUCTION

Depending on the usage of renewable energy resources paves way for reducing the amount of production of greenhouse gases. On the other side, consumption of electricity has been raised. The concept of energy production from renewable energy resources has been introduced in order to overcome this issue. Several researches and initiatives have been made to increase the usage of this alternative resource. This paper deals about the wind energy conversion and four MPPT techniques used to harness wind energy.

WECS converts one form energy into other form of energy. Wind turbines converts Kinetic energy of wind into mechanical energy. The produced mechanical energy is again converted into electricity by the use of generators and it is further fed into grid. Following introduction section the paper has further two sections. Wind Power characteristics in section II, MPPT Algorithm in section III and conclusion in section IV.

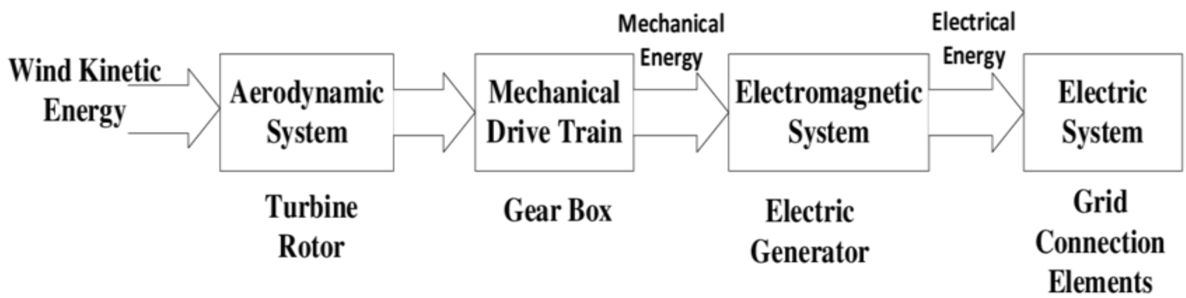

Figure 1: Wind Energy Conversion System

Two separate MPPT techniques are used to operate small-scale WECS connected to DC-Bus that are based on PMSG [1]. Modelling of the system has been carried out using Matlab. A hybrid system simulated using PI controller and MPPT Controller. The system is simulated with several MPPT techniques [2].

Wind energy conversion system is proposed with buck converter and modelling of buck converter is simulated using Matlab [3]. Modelling allows MPPT controller to adjust the duty cycle of the converter. Techniques for choosing suitable MPPT algorithm has been discussed in [4].

PMSG generator is simulated using boost converter. HCS based MPPT technique is used to vary duty cycle according to the voltage and current parameters. Simulation results are obtained for both fixed and variable wind speeds. This method prevents the usage of sensors which increases the cost of the system by controlling duty cycle of DC-DC converter. The system's simulation results are compared with and without utilizing MPPT, and the system employing MPPT provides greater output than the other [5].

A wind turbine with a variable speed PMSG is built using a hill climbing searching MPPT algorithm. This method achieves maximum output power. Implemented FLC makes the system to work efficiently under complex situations [6].

A unique MPPT method was introduced in detail to improve the power extraction and lower mechanical damage for wind turbines based on accurate tracking of rotor speed probability density function (PDF) form for wind turbines. The new MPPT control law is intended to make the PDF shape of the rotor speed monitor the desired PDF shape as precisely as achievable. It is used to track the change in wind speed accurately by neglecting the wind speed characteristics [7].

Intelligent Control system is designed to provide information about future wind speed to Model predictive Controller to maintain smoother power generation. Control system is implemented to control pitch angle of wind turbine [8].

Wind energy conversion system is implemented with the combination of slide mode control technique and fuzzy logic controller to increase the robustness. A small strategy is followed to increase the efficiency of system in lower wind speed areas [9].

Drawbacks of Hill-climbing algorithm has been overcomed by introducing Grey wolf optimizing algorithm. Results obtained from Grey wolf optimizing algorithm are compared with grasshopper optimization algorithm (GOA), Cukoo search (CS), Electric charge particle optimization (ECPO). Among the other optimizing techniques GWO-MPPT controller provides more efficiency [10]

Eleven types of MPPT algorithm are discussed and classified into direct, indirect or hybrid power controller. This paper favours for choosing the right MPPT technique based on their application [11].

Wind energy conversion system is simulated using three types of controllers like PI, P&O and FLC with buck converter for varying wind speed conditions. Output results of three controllers are compared. It shows that results generated by FLC are more efficient than other technique. P&O algorithm is suitable for wind condition with lower variance [12].

Control techniques are implemented using Proportional-integral-derivative (PID), Optimal Torque and Fuzzy logic. This article gives a general overview of control methods and performance enhancements for horizontal wind turbines [13].A stand-alone wind energy system with hybrid dc-dc energy storage. Vector control strategy is used to extract maximum power from wind. The presented method provides rapid response to wind and load changes [14].

This paper presents about grid connected wind energy conversion with incremental conductance. New structure of Multi Level Inverter which reduces THD. Inverter enhances the power quality of the system [15].

II. WIND POWER CHARACTERISTICS

Output Power obtained by wind can be expressed by the formula

$$P = c_P(\lambda, \beta)\frac{\rho A}{2}V^3 \qquad (1)$$

P is the output power of wind turbine, C_p is the performance co-efficient of wind turbine, ρ is Air density in (Kg/m^3), A is turbine swept Area(m^2), V is speed of wind in (m/s), λ is tip speed ration of the rotor blade tip Speed to wind Speed, β is the blade pitch angle in degrees.

Tip speed Ratio (λ) is defined as the product of rotational speed of wind turbine (ω) and radius (R) to the ratio of wind speed (v).

$$\lambda = {}^{\omega R}/_{v} \qquad (2)$$

The power curve characteristics depends on the ratio of wind speed and power produced by turbine. The speed at which the turbine starts to generate power is called cut-in speed. Speed at which the turbine produces the rated output power is known as Rated output speed. Speed at which the turbine rotates beyond the rated speed is known as Cut-out speed. Generally at this time, turbine stops generating power. Power curve characteristics of wind turbine is presented in Figure 2.

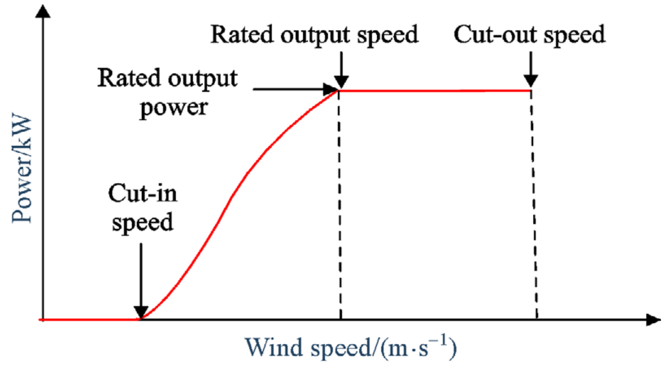

Figure 2: Power curve characteristics of Wind Turbine

III. MPPT ALGORITHM

Using a power source with a fluctuating power profile can be effectively utilized by using a family of control algorithms called maximum power point tracking. By measuring the dc link power, the maximum power point tracker (MPPT) draws the greatest amount of power possible from the wind turbine from cut-in to rated wind velocity. As renewable energy systems ability to supply power changes significantly and in an unpredictable way, such as photovoltaic plants or wind turbines, Maximum Power Point Tracking (MPPT) is frequently used in these systems.

Generally four major algorithms used in Wind Energy conversion systems,

1) Tip Speed Ratio (TSR) Algorithm
2) Perturb and Observe (P&O) Algorithm
3) Optimal Torque (OT) Algorithm
4) Fuzzy Logic Control (FLC) Algorithm

Tip Speed Ratio (TSR) Algorithm

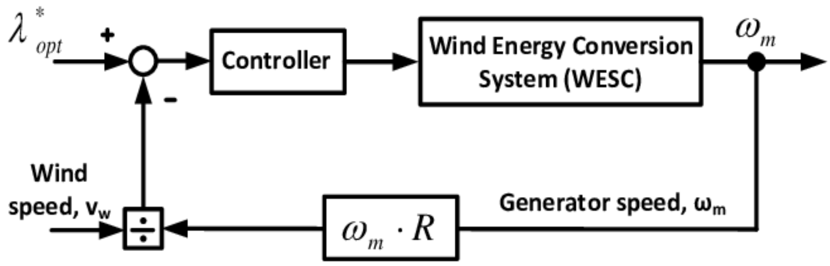

Figure 3: Tip Speed Ratio Control

Tip Speed Ratio Control Method adjusts the rotational speed of the generator in order to maintain TSR at a desirable value to which the maximum power is extracted. This method requires the measures of both wind speed and turbine speed. Along with TSR pitch control is implemented in [16].

Perturb and Observe Algorithm

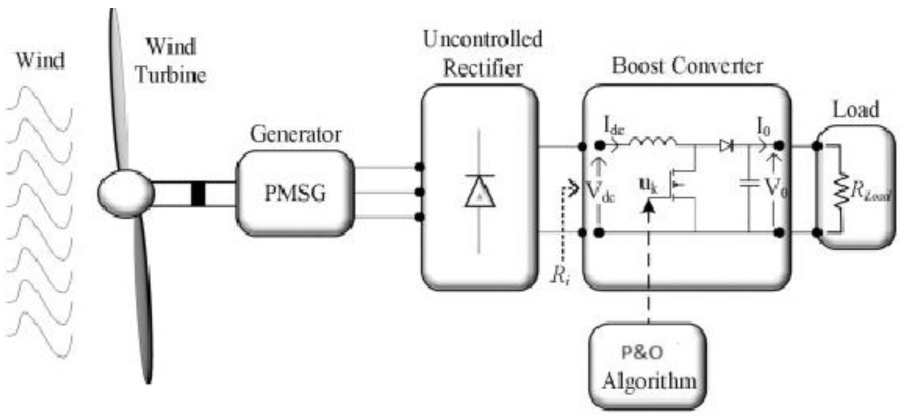

Figure 4: Block diagram of Perturb and Observe Algorithm

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Block diagram of Perturb and Observe Algorithm is displayed in fig 4. P&O algorithm operates systematically with incrementing or decrementing the current and voltage parameters.

Perturb and Observe algorithm is the simplest algorithm where it does not require prior knowledge on wind energy conversion. This algorithm is also known as Hill Climb Search Algorithm. This algorithm does not require any speed sensor. This method observes the variations in output power and adjusts the duty cycle of dc-dc converter in order to adjust the speed of the rotor. If a suitable power P variation are positive, a change will be made that will take place in the direction of the maximum power point and continue variations along that same path until MPPT is reached. The direction of the perturbation has to be modified if the change in P is negative because this indicates that the MPP has experienced a significant modification. Working of P&O Algorithm is represented in figure 5. Hybrid MPPT algorithm using P&O and ORB in [17] to overcome the drawbacks of the system.

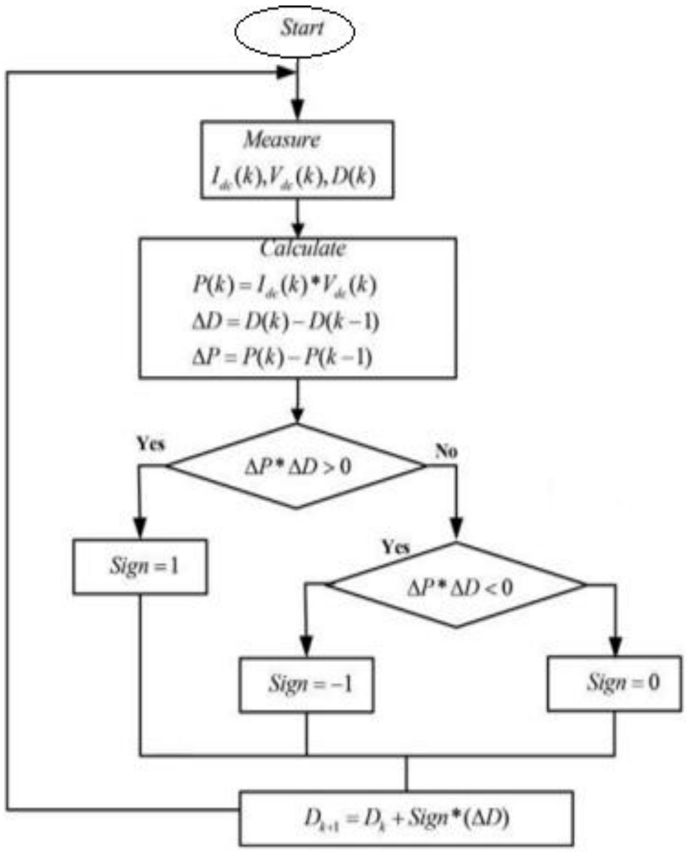

Figure 5: Flow chart of Perturb and Observe Algorithm

Optimal Torque algorithm

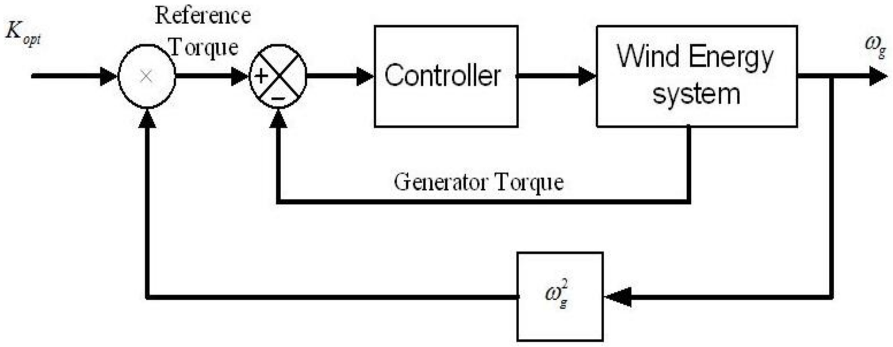

Figure 6: Optimal torque Control

With the OTC approach, the generator's torque is managed to generate the most effective torque reference curve in accordance with the wind turbine's maximum power at a specific wind speed. Equation can be used to

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determine the turbine's ideal mechanical torque, which is then provided as a reference torque for the wind turbine's MPPT controller. The controller receives the control signal by subtracting the ideal reference torque from the actual torque, which minimize the difference between the two. Strategies involved in Optimal torque Algorithm are discussed in [18].

Fuzzy Logic Control Algorithm

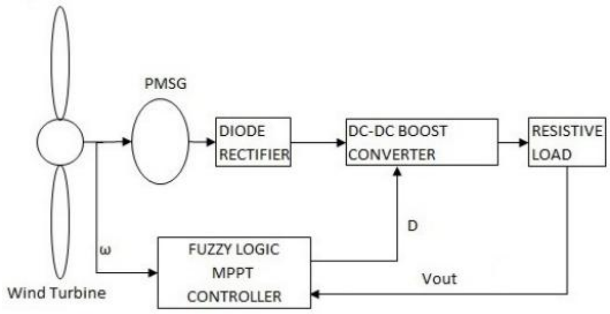

Figure 7: Fuzzy Logic control Algorithm

The area of application of fuzzy set theory, fuzzy reasoning, and fuzzy logic with the most active body of study is called fuzzy logic control (FLC). When compared to traditional control methods, FLC has proven to be most effective in complex ill-defined issues that a skilled human operator can manage without being aware of the dynamics at play. Fuzzy Logic controller implemented in [19]. Implemented Algorithm provides suitable duty cycle D to DC-DC Boost converter to control the speed of PMSG generator. Design of FLC algorithm plays major role in tracking good accuracy for variable wind conditions.

COMPARISON OF MPPT TECHNIQUES

Table 1: Comparison of MPPT Techniques

S. No	Algorithm	Complexity of the system	Wind speed Measurement	Performance under varying wind conditions	Prior Knowledge
1	TSR	Simple	Yes	Average	Not needed
2	P&O	Simple	No	Average	Not Needed
3	OT	Simple	No	Average	Needed
4	FLC	High	Depends on	High	Needed

IV. CONCLUSION

WECs uses maximum power point tracking techniques to improve energy extraction and hasten convergence. A review of some algorithms has been presented in this paper. Comparison of complexity among the system has been displayed. TSR, P&O, OT algorithms are simple to implement than Fuzzy Logic Controller Algorithm. FLC works efficiently on varying wind conditions than that of other discussed algorithms.

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