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Different Technique of Maximum Power Point Tracking (MPPT) For Wind Power Generation

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Abstract — *this paper is nominate a new different method an improved maximum power point tracking (MPPT) method for wind power system. A different control method for MPPT of wind turbine adjusting load characteristic was nominated in this paper. In different methods of MPPT; By using algorithm employed in wind energy conversion system(WECS) the major effect concerning Hill Climb Search (HCS) is it's inefficiency in detecting peak power when there change wind speed. The HCS generate oscillations in delivered power once of this peak value detected. A modified HCS algorithm is nominated in this paper to overcome these limitations. In this algorithm used a variable duty cycle to reduce the oscillation in delivered power once the maximum power point (MPP) is detected ; The wind power management system based on DC to DC convertor was designed .The MPPT pull maximum power from the wind turbine from cut in to variable wind velocity by sensing only DC link power .The maximum power point (MPP) step and search algorithm in addition to the DC to DC are simulated generate by using METLAB software and result generate show that the DC to DC converter topology can generated the maximum power tracking control of the wind turbine ; MPPT method with hysteresis control, the hysteresis controller is similar to that used in the typical P&O (production & observation) control. This method is control the output of wind turbine is unable to reach maximum power, in hysteresis controller different duty ratio within the hysteresis band to correct for operating point by using control method; MPPT by using fuzzy logic controller (FLC), in this method for MPPT a fuzzy logic control is nominated for maximum power tracking in wind turbine control to permanent magnet synchronous generator (PMSG). By using FLC tracks the MPP by measurement the load voltage and current, this controller calculates the load power and transfer through the fuzzy logic system. In this paper by using this method main aim is design of the FLC controller in the mode of boost converter (DC-DC converter). FLC method is allows the MPPT controller output (duty cycle) adjust the voltage input to the converter to take MPP of wind power generating system.*

Keywords- *HCS; MPPT; TSR; WECS; DC to DC converter; FLC; PMSG; MATLAB-SIMULINK.*

I. INTRODUCTION

Nowadays renewable energy is developed because of fossil- fuel is exhausting pollution in environment, it's very harmful and creates a green house effect and other environmental problem. This environment effect by fossil- fuel is overcome by using renewable energy i.e. wind and solar energy. But some limitation of energy conversation system, such a wind power and solar power are their inability to track peak power production efficiently at varying wind speed and solar insulation respectively. This limitation is reducing by different **Maximum Power Point Tracking (MPPT)** control method. In this paper four method are used a tracking and controlling MPPT for wind power system shown below:

- MPPT algorithm
- DC to DC control converter
- Hysteresis controller
- Fuzzy logic controller (FLC)

II. BASIC KNOLAGED OF WIND POWER SYSTEM

2.1. The relationship between the rated speed and rated power

The rated power of wind power generation is,

$$P = \frac{1}{2}\rho A V^3 \quad \text{.....(1)}$$

Where, ρ is density of air (kg/m^3); A is rotor rotational areas (m^2) ; V is wind velocity(m/sec). In this physic power equation the air density is proportional to the air temperature and air pressure both varied with height above the sea level. The power in the wind cannot be completely into mechanical energy of a wind turbine. So that theoretical maximum of energy extraction from wind was discovered Betz in 1926, and it's defined as;

$$P = \frac{1}{2}\rho A V^3 \; C_P \quad \text{.....(2)}$$

Where, C_P power co-efficient. According to Betz, even if no losses occurred a wind turbine could utilize only 59% of wind power. In addition when unavoidable swirl losses are include, this figure reduced to about 0.42. This happens to observes as current limit of well designed turbines today.

$P = \frac{1}{2}\rho A V^3 \times 0.59$ …..(3)

2.2. Variable speed wind turbine and Tip speed ratio

Wind turbine original modal were it is a fixed speed turbines; in this turbine the rotor speed was a constant for all speed. Equation of tip speed ratio for a wind turbine is,

$$\mathrm{TSR} = \frac{\text{Linear speed of blade outermost tip}}{\text{Free upstream wind velocity}}$$

$$\mathrm{TSR} = \lambda = \frac{\omega R}{V}$$

….. (4)

Where, ω is rotor speed; R is length of blade; V is wind velocity. In fixed speed wind turbine (WT), value of the TSR ratio only varied by wind speed variation. In according to a C_p-λ it's a defined as the relationship between tip speed ratio and efficiency, It is defined that only one value of λ yields the maximum efficiency. Fixed speed wind turbine does not operate at maximum efficiency across a range of wind turbine were developed. Since TSR is given by the aforementioned expression, variable speed wind turbine can operate at maximum efficiency over all wind speeds. Shown Fig 1. The below is an illustration of C_p-λ curve for typical wind turbine. Variable speed is providing the ability to convert the rotor speed.

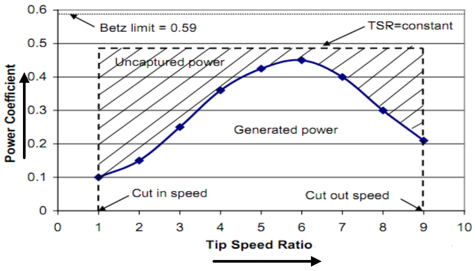


Fig 1. Power co-efficient as a formation of TSR

2.3. Basic block diagram of wind turbine generation connected to converter

Power electronic converter stage between the turbine and grid shown in Fig 2. WTG system to operate constantly near to its optimal tip speed ratio.

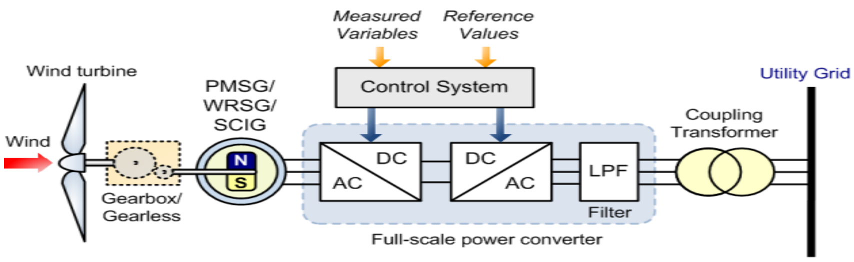


Fig 2. Basic block diagram of wind turbine generation connected to converter

III. MAXIMUM POWER POINT TRAKING (MPPT) ALGORITHMS

The following topic describes the different conventional methods of MPPT in wind energy conversion system (WECS):

3.1 HCS method

HCS method of MPPT makes use of the invert U-shape graph between power and rotor speed show in Fig 3. As there is a different maximum power responding to particular rotor speed, the algorithm compares the present compare the present power at an instant to power obtain at the previous step. If the power to be increasing then the duty cycle of gating pulse applied to the converter switches are increased to drive the operating point more towards the maximum power and power to be decreasing them the duty cycle is reduced. The method is simplicity and independence from wind turbine characteristics, it's a primary advantage and a disadvantage of the HCS method is its inability to track them MPP. In case of abruptly varying wind conditions. In simple HCS method the increment /decrement given to the duty cycle are fixed.

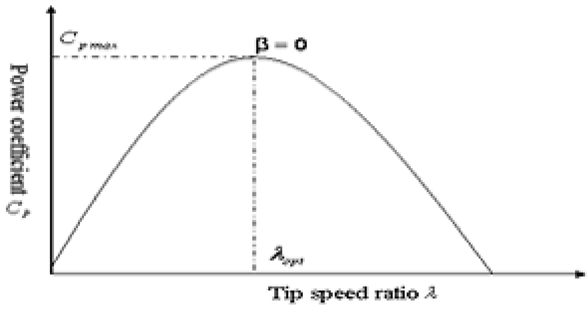


Fig 3. Invert U-shape graph between power and rotor speed

3.2 TSR method

TSR method tries to implementation the rotational speed of generator control an optimum TSR. Disadvantages of TSR method is that wind speed need to be known along wing the turbine rotational speed measurement. This ingress to the system cost, and it's only used for small scale wind turbine.

3.2 Power signal feedback (PSF) method

Its method used a reference power, which is the MPP at particular wind speed. This in itself presents an take, as the prior knowledge of wind turbine characteristic power obtained from the power curve for a particular wind speed and compare with the present power yield is done. The error is created then drives a PI control defined to proportional (P), integral (I) control. It has a 'P' and 'I' part that are manipulated to reduce the instantaneous values.

3.3 Nominated algorithm

Due to the principle of wind energy system, the power is available only the wind turbine is depend on wind speed and rotor angular speed β. In wind energy power system wind speed being uncontrollable , only the operating point is to control the rotor speed using a power electronic to control the rotor speed on loaded generator. Without any given knowledge of the aerodynamic of any wind power system, the method of HCS principle search for the MPP by adjusting the operating point and observing the corresponding change in turbine output. Its depend on the natural power curve of the turbine. The maximum power point (MPP) is defined by the power curve in Fig 4.

Where, $$\frac{\Delta P}{\Delta \omega} = 0$$ …..(5)

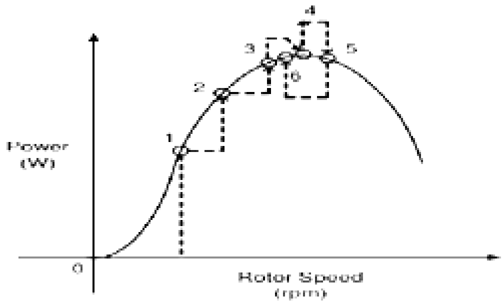


Fig 4. Wind power curve for an arbitrary wind speed

Thus, the objective of HCS is to 'climb' the curve by varying the rotor angular speed β and measuring the output power until the condition of $\Delta P/\Delta\omega = 0$ is met. The algorithms create the reference speed by measuring the output power of wind energy conversion system operating point accordingly. The maximum power condition $\Delta P/\Delta\omega = 0$ is archived when $\Delta P \approx 0$ because the amount of adjustment in the rotor speed is chosen to be the various in power. Thus where $\Delta P, \Delta\omega \approx 0$. The algorithm flowchart show in Fig 5.

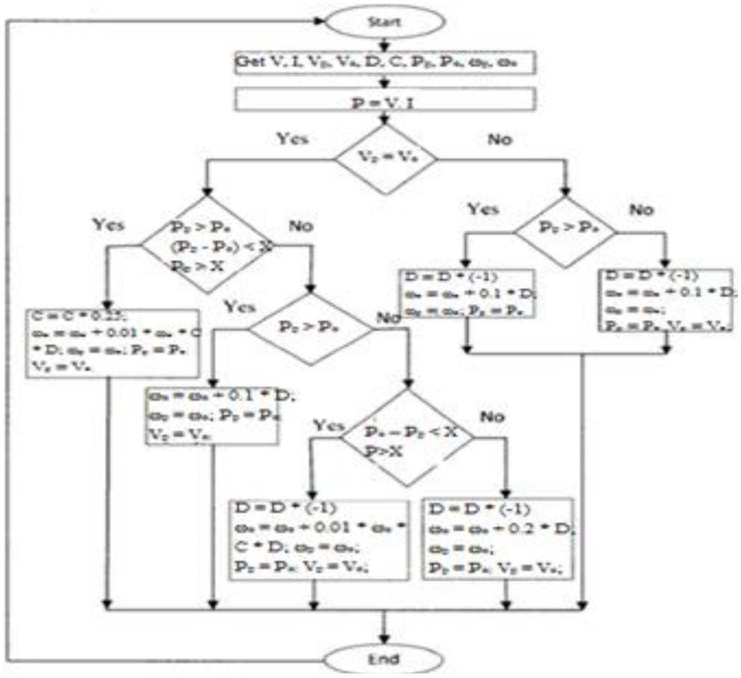


Fig 5. The algorithm flowchart

The system at a point-1 and chooses to increases the rotor speed to point-2 observing that the output power by increasing the rotor speed, the algorithm signals to further increase the rotor speed to point-3. Since $\Delta P/\Delta\omega$ is positive, so the system is climbing up the power curve. With $\Delta P/\Delta\omega$ still positive the system continues to increase the rotor speed to point-5.the algorithm is defined that the changing in power at point-4 and point-5 is negative and it was due to an increase in now speed. $\Delta P/\Delta\omega$ Now negative the optimum point has been passed. As a result the rotor speed is find to point -6 .the slope of the power curve diminishes as the system approaches the MPP. Therefore it was following that as the operating point moves closer to MPP at point-4. The magnitude of speed adjustment should be smaller; the algorithm will oscillate and eventually set at the maximum power point (MPP).

IV. DC to DC converter controller for MPPT

The DC to DC converter is core part of wind power MPPT controller. Its dynamic characteristics have an impact on the system. It is based on the theory on nonlinear dynamic wind power system. Using periodic switching system model analysis of the hybrid dynamic characteristics of DC to DC converter and study the system's controllability, observability and reach ability. The study on hybrid control problem of boost power converter through the design of hybrid control law for regulating output voltage of the control converter. It is based on sliding mode observer established hybrid system state model of DC to DC control converter for MPPT.

4.1 Control design for wind power system

Wind power system control by using DC to DC control converter show Fig 6. Grid –connected wind power system. The back EMF of the wind generator is comprised of a three phase sinusoidal voltage that is converted to DC voltage (V_{in}) by a diode rectifier (AC to DC converter) .the MPP is control performed by adjusting the duty cycle ratio of DC boost converter on the DC side.

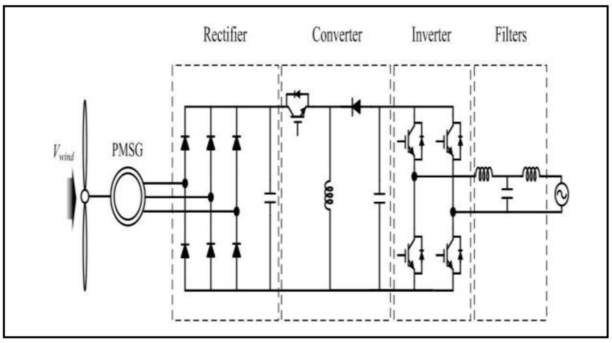


Fig 6. Grid –connected wind power system

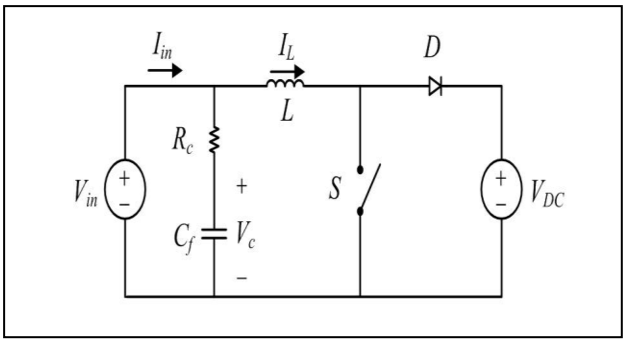


Fig 7. Equivalent circuit of the DC-DC converter

Show Fig 7.equivalent circuit for the boost converter for the wind generator control. The boost converter control V_{in} by using the current or voltage control. The DC-link voltage V_{dc} is controlled by a grid-connected inverter (AC to AC converter).

4.2 MPP controller and DC to DC converter controller

According to formula no-2 curve shown in Fig 8. For wind speed (ω) under variable wind speed. All wind speed has maximum power point (MPP). These MPP are connected by curve, the changing in wind turbine (WT) output power relative to change of the speed is zero and it expressed as,

$$\frac{dP}{d\omega} = 0 \quad \text{.....(6)}$$

The input voltage (V_{in}) and duty cycle ratio of DC converter will be express in following formula,

$$D = 1 - \frac{\mathrm{Vin}}{Vout} \quad \text{..... (7)}$$

Where the D is duty cycle ratio of DC converter; V_{in} input voltage of the DC converter and V_{out} voltage DC converter.
Transform the formula (6) as below,

$$\frac{dp}{d\omega} = \frac{dp}{dD} \times \frac{dD}{dVin} \times \frac{dVin}{d\omega 1} \times \frac{d\omega 1}{d\omega} = 0 \quad \text{..... (8)}$$

Where the ω_1 is the angular velocity of the wind generator,

$$\frac{dD}{\mathrm{Vin}} = -\frac{1}{Vout} \neq 0 \quad \text{..... (9)}$$

Proportional relationship between the input voltage of DC converter and wind generator EMF. We can get,

$$\frac{dVin}{d\omega 1} \neq 0 \quad \text{..... (10)}$$

So, the prove that theory the mediation of converter duty cycle ratio to achieve the MPPT control of the wind turbine.

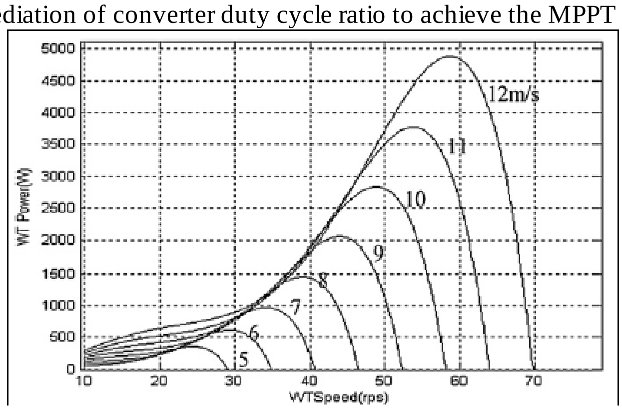


Fig 8. Typical power different speed characteristics of a wind turbine

4.3 Simulation

The METLAB simulink result with the MPPT in addition to comments will them be given for two wind speed 6,8 and 10 m/s. the electric machine and the DC to DC converter parameter are given in appendix. Show in Fig 12. Controller is able to search for maximum power and keep the co-efficient of the wind turbine is much closed.

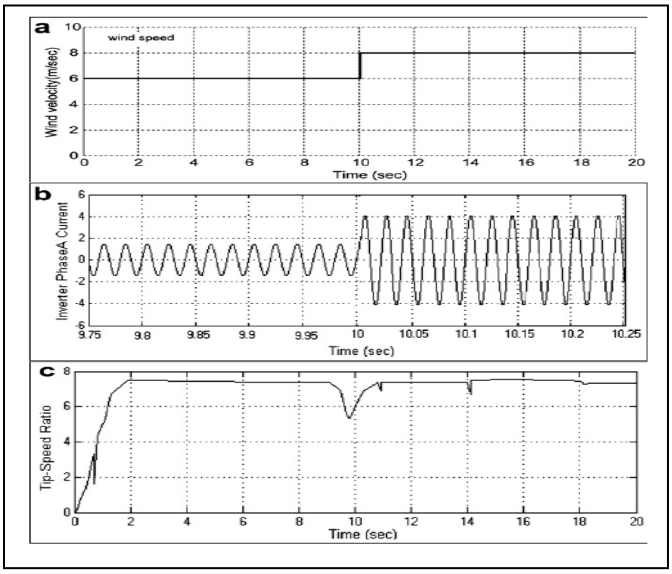


Fig 9. MPPT for step changing in wind speed

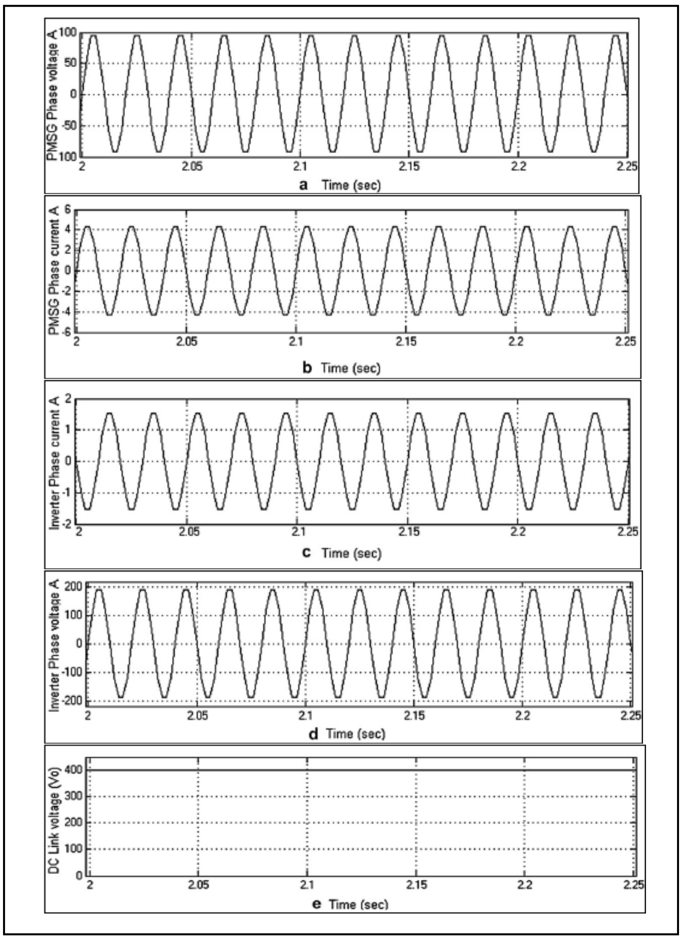


Fig 10. Simulation result for wind speed 6 m/s

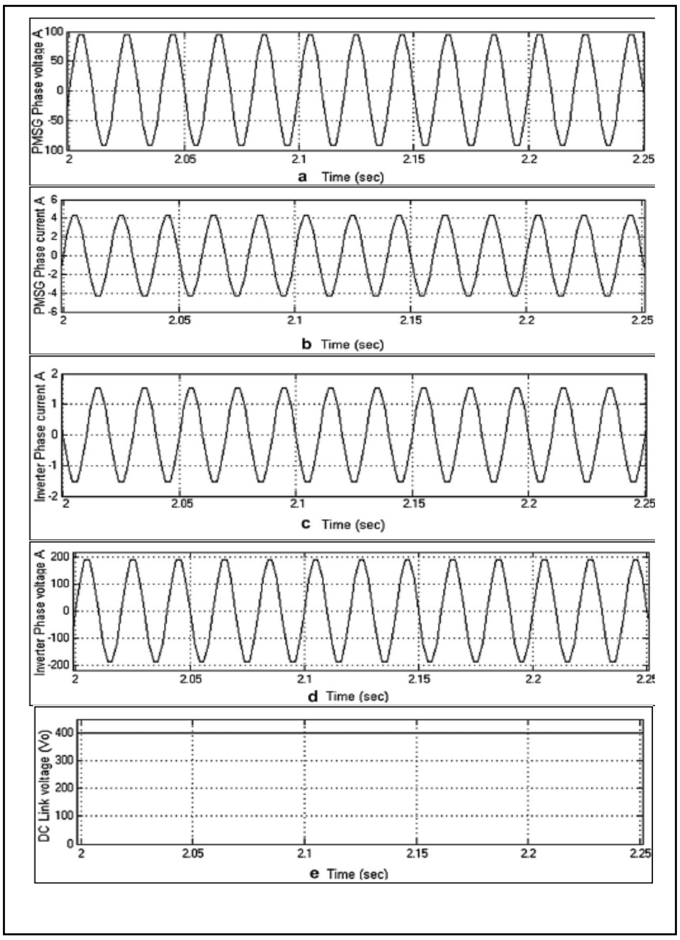


Fig 11. Simulation result for wind speed 10 m/s

V. MPPT method with hysteresis control

MPPT method using TSR control can rapidly track the maximum power point (MPP). However this MPPT method cannot guarantee the operation of the controller at the maximum power point when the error occurring in C_p –curve are caused by a variance in the blade characteristics the hysteresis is controller is combined with TSR control to solved this problem.

In this controller monitor the power output in order to have a chopped of maximum power when the wind turbine operates at the maximum power point of the modeled C_p –curve using TSR control, and the output of wind turbine is unable to pull maximum power, the hysteresis controller varies the duty cycle ratio within the hysteresis chopped to correct for operating point. Show the Fig 12. The mechanism by which hysteresis control occurs.

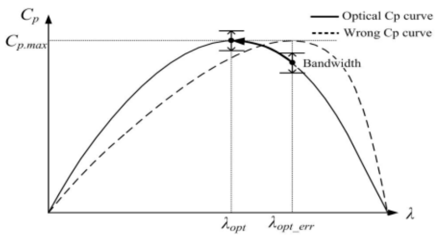


Fig 7. The mechanism of hysteresis control

The nominated MPPT control step:

Step 1: When the changed wind speed makes reference to the current that is derived from the alternative power coefficient curve from that earlier, the controller operates under TSR control mode;

Step 2: If the change in wind speed, or the error of the TSR controller, is within certain bandwidth, the controller operates under hysteresis control mode;

Step 3: If the change in power coefficient is within a certain bandwidth, the controller operates under fixed speed mode.

VI. Fuzzy logic control for MPPT

One the method to achieve the MPP, this is a turbine blade pitch angle β can be controlled but for a low power is impossible due to mechanical problem generated. So, to achieve MPP at low power turbine must be used the power control method. Now, the MPPT control methods generally used are TSR, optimal torque control (OT) , PSF and DC to DC control converter method etc. the TSR, OT, PSF, DC to DC control method due to mechanical sensor, and this method is independent of the characteristics of the turbine and generator. In this method nominated a MPPT control strategy which predict the MPP make used of fuzzy logic without mechanical sensors.

6.1 Wind turbine modeling

Show the Fig 12. The curves of the wind turbine power curve, the maximum power are attain at the variable rotor speed. So, the rotors speed. This method is called MPPT.

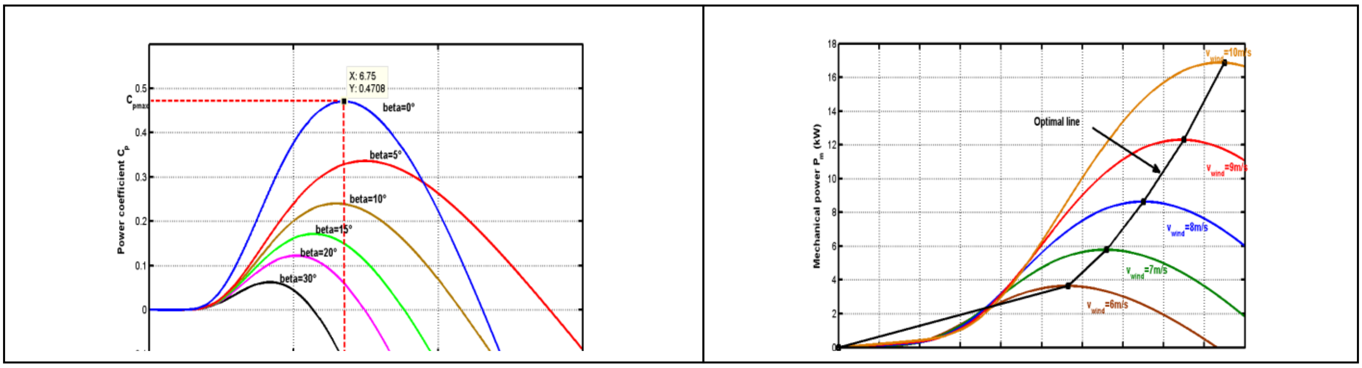


Fig 12. The power curve for different wind speed and zero bitch angle

The generator AC output is converted in DC using a 3-phase full wave bridge rectifier (AC to DC converter). Using DC to DC converter to control the output voltage of the rectifier V_{dc} is applied DC output voltage and current are measured send to the fuzzy algorithm used to the controller. In this method, the fuzzy algorithm used to gating the MPP. In this method the load voltage and current measured and output sent to the controller show in Fig 13. The block diagram of the controller used in this case.

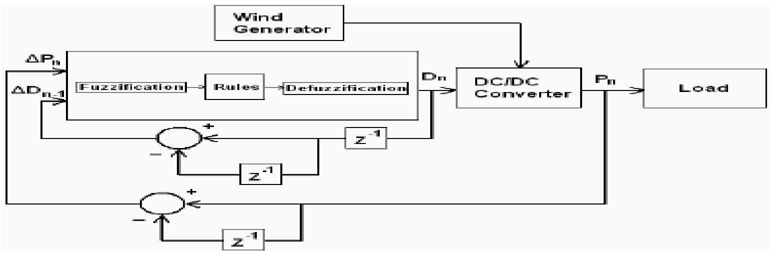


Fig 13.The block diagram of the controller used in this case

In this process of fuzzy membership functions with a varied between 0 and 1 is used to convert the controller's.

6.2 Maximum power point control of FLC

Show in Fig 14. Present the block diagram of WECS in this method, wind energy convert using wind turbine. mechanical power by PMSG in electronic energy.

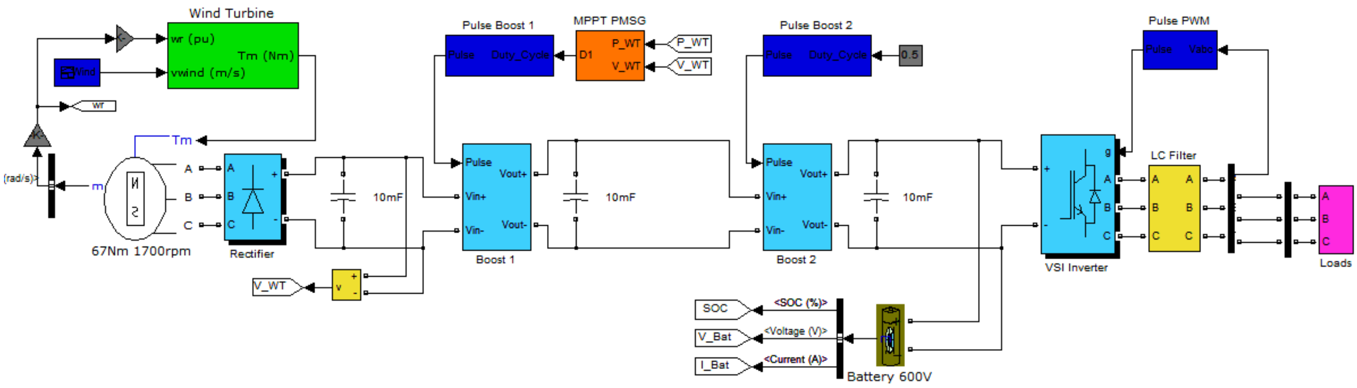


Fig 14. Simulation in METLAB Simulink

6.3 Fuzzy algorithm to achieve MPPT

A new approach was nominated for MPPT which is independent of the characteristics of the rectifier then, searches the MPP. Input differential value ranging. Using FLC memberships function and take to be of triangular for reasons of simplicity. It is less demanding in competition in computation resources. Two inputs for the fuzzy logic controller are the output power variation, ΔP_n and the convert's output duty cycle different ΔD_{n-1}.

$\Delta P_n = P_n - P_{n-1};\quad \Delta D^1_n = \Delta D_{n-1} - \Delta D_{n-2}$ …..(12)

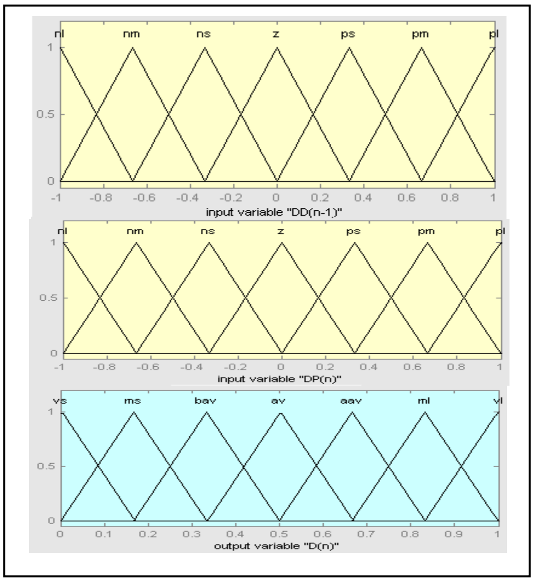


Fig 15.Membership function for fuzzy variables

For the fuzzy inference engine "IF-THEN" rules with "AND" logical operation and designed for the fuzzy variable operation.

ΔD_n^i	ΔP_n						
	nl	**nm**	**ns**	**z**	**ps**	**pm**	**pl**
nl	vl	vl	ml	bav	ms	vs	vs
nm	vl	ml	aav	bav	bav	ms	vs
ns	ml	aav	aav	av	bav	bav	vs
z	vs	ms	bav	av	aav	ml	vl
ps	**ms**	bav	bav	av	aav	aav	ml
Pm	vs	ms	bav	aav	aav	ml	vl
pl	vs	vs	ms	ml	ml	vl	vl

Table 1. Fuzzy rules

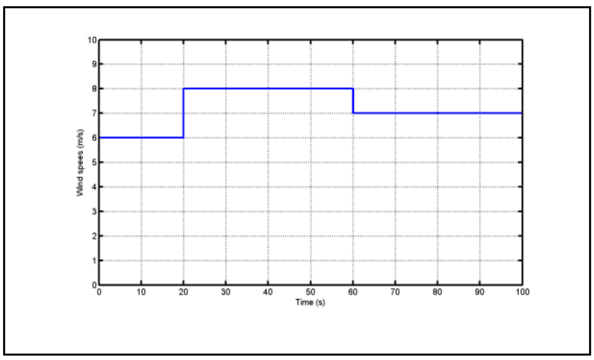
6.2 Simulation

The simulation of WECS with MPPT control is simulation by using MATLAB simulink as show Fig 16. Wind turbine, as a using permanent magnet synchronous generator (PMSG). 3-phase full bridge AC to DC convertor, Boost DC to DC and MPPT controller. Table 2. The parameter of the wind turbine and PM-synchronous generator.

Turbine rated power	2.5	kw
Rated wind speed	12	m/s
Optimum power coefficient	0.48	-
PMSG- rated power	3	kw
L_d, L_q	0.435	mh
p	4	-

Table 2. The parameter of the wind turbine and PM- synchronous generator

In this simulation, wind speed varied in three steps, wind speed at time t_1 = 0.5sec and t_2 = 0.8sec is change from time 14sec and 12m/s and then to 10m/s is reduced, with the various wind speed. The performance of wind turbine with FLC can tack the maximum power delivery operating point.



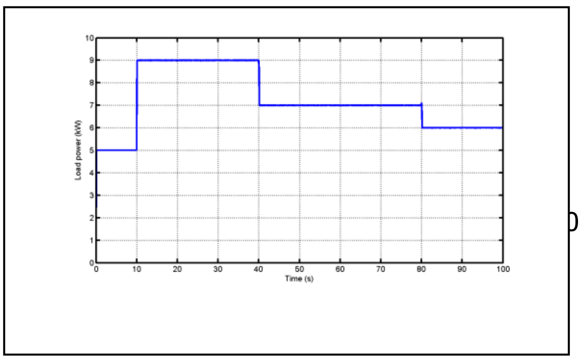


Fig 16.Wind speed

Fig 17. Load demand

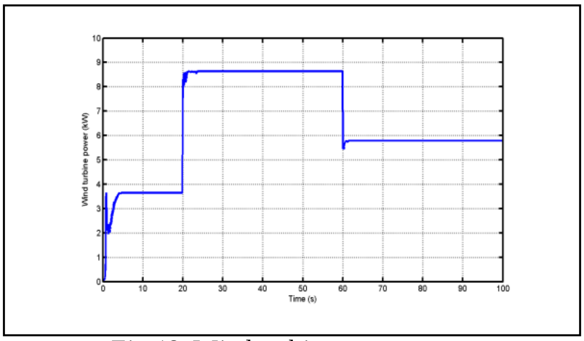


Fig 18. Wind turbine power

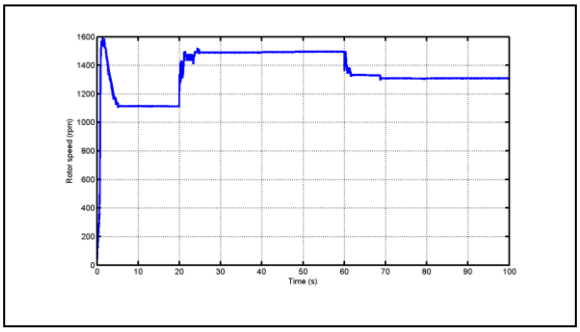


Fig 19. Rotor speed

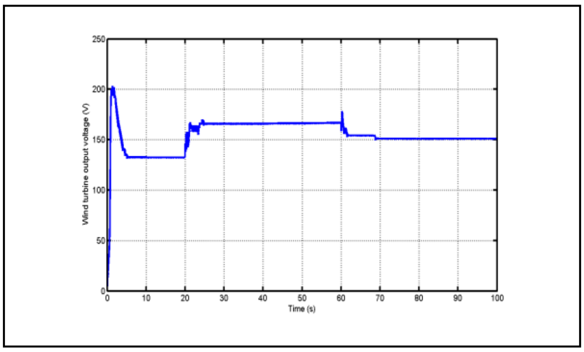


Fig 20. Wind turbine output voltage

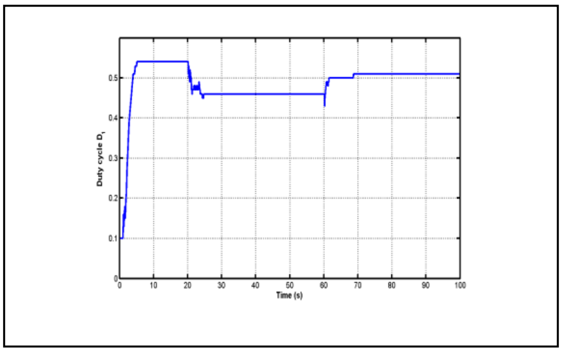


Fig 21.Duty cycle D_1

VII. CONCLUSION AND FUTURE SCOPE

In this paper I have nominated four methods of MPPT of wind power system. First method, MPPT algorithm a wind turbine system does not naturally operated. At its most efficient operating point and due to the shape of wind turbine power curve a significant amount wind power can be left unharnessed. And solution to this problem, the nominated algorithm used a modified different of an established concept known as the HCS algorithm. In DC to DC control converter, using a DC controller can realize the aim that wind turbine output power tracking the maximum theoretical power. Wind turbine power co-efficient C_p and duty ratio has remained near the optimal value in wind power system design. In Hysteresis controller, when hysteresis control method can compensate for current control using a C_p- curve based on incomplete data. In fuzzy logic control method MPPT technique can get maximum power is described and verified by using the simulation. The nominated method is completely independent of the properties of turbine and generator. This new MPPT doesn't use the wind speed measurement but voltage and current load is measured. So this method is not any mechanical sensor which will result in reduce the cost and increased the reliability of the system. Control strategy is comparatively different methods of MPPT is easy and has high practical value. Simulation results show that in any atmospheric condition such as wind speed change the wind turbine system can run stable and take a maximum power as compared to above nominated three methods.

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