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Comparative Study Of Various Controllers On Variable Speed Wind Energy Conversion System.

Kriti[a], Sawan Singh[b], Prakhar Gaur, Pratik Kumar[d]
Department of Electronics and Instrumentation Engineering Galgotias College of Engineering and Technology, Greater Noida, India
[a]kriti@galgotiacollege,edu,[b]Sawansingh5569@gmail.com,[c]Prakhargr@gmail.com [d]ikumarpratik1@gmail.com

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***Abstract*- In this paper, we have compared the parameters of the Wind Energy Conversion System (WECS) using different controllers. Controllers in WECS are implemented to control a permanent-magnet synchronous generator (PMSG) that is powered to load through a converter. First priority of controllers is to extract maximum power output under fluctuating wind speed. Controllers such as pitch controller, PD, PID and FLC are applied to variable speed WECS models in MATLAB SIMULINK. Output using different controllers provides comparison between relative parameters like settling time, rise time steady state error and power factor. Result also provides performance of controllers in steady and transient state. Pitch angle is the controlling parameter for all the controllers which is important to eliminate possible danger due to sudden change in wind speed.**

***Keywords*-WECS(Wind energy conversion system), PID(Proportional integral derivative), FLC(Fuzzy logic controller), Pitch.**

I. INTRODUCTION

Nowadays various sources of renewable energy are present and different energy conversion methods have been studied but energy conversion through wind has a greater demand. Wind energy conversion system is the most efficient and cost effective energy source. It converts the energy of wind movement into mechanical power. The output power has various applications and areas of use such as wind turbines that can produce power for a single home or building or even can be connected to the electrical grid for more widespread electricity distribution. It has some most important parts such as the turbine gearbox, the rotor and the pitch control. Different controllers can be applied on the wind energy conversion system to reduce the complexity as well as to get the desired output power. Variable speed wind energy conversion system allows us to apply the controllers and optimize the output power in the particular region and to extract and to extract the maximum from there, so different controllers such as pitch controller, PID controller, PI and PD as well as fuzzy controller have been applied to the VSWECS and the comparison has been done using the output from the matlab simulink and the comparison on the basis of various factors have been considered in this paper.

The main concern is to control the power within the condition of variable wind speed within the safe region, regions are divided into two important parts, region 2 is the cut in and the rated regions in which the rotor speed is controlled by controlling the generator torque and then there is region 3 that is the rated and the cutoff region in which the optimal pitch angle control is the main area of control. So various controllers are being applied and tested and compared to get the best optimization and power output in variable wind speed conditions.

II. LITERATURE REVIEW

A system was proposed in [1] to calculate potential thermal source in an simple way .This system useful for evaluating the energy generated remotely and here the main aim was to early evaluate the potential energy source and for that the PID controller was replaced with the Fuzzy-PI controller for this work and for this many tests were done and were found that fuzzy-pi controller were more faster and efficient up to 50% than the PID controller, It was observed that fuzzy controller got a steady state error 53% smaller than the PID Controller. Et al. A.Beddar, The main concern is to control output power in the condition of variable wind speed in safe region, the regions are divided into two important parts , region 2 is the cut in and the rated regions in which the rotor speed is controlled by controlling the generator torque and then there is region 3 that is the rated and the cutoff region in which the optimal pitch angle control is the main area of control[2]. The pitch control system is used in wecs for optimizing the generator output power, reducing load fatigue, this can be done by reducing the rotor speed by changing the pitch angle of the blades using the PID controller but due to non linearity in the wind it is difficult to design the PID controller so, here type 2 fuzzy controller is used and on comparison it is found that it handles the uncertainties more better and shows accuracy far more better than PID controller. The results have also shown that type 2 fuzzy has better control over pitch. Using a fuzzy controller helps in obtaining the maximum power output using MPPT and also that fuzzy logic can be applied to more than two renewable resources[3]. Et al Zhihuan Chen did Comparative study between the fractional order proportional, integral derivative and optimum integer order PID controller is done and the results shows that the optimum fractional PID is superior over other integer controllers, this can be the best alternative for the controllers[4]. The turbine's shaft speed is stepped up with the help of this. This is used in wind energy conversion system to make rotor speed constant and also work as a medium to transfer torque generated by the shaft to the generator.
The application of MPPT in WECS using PID was covered in [5] and observed that the maximum power was extracted when the utmost peak power is tracked by the MPPT or basically the power extracted depends on the amount of peak power tracked by the MPPT which is again depended on the rotor speed controlled by the MPPT controller.[5].

III. MODELING

The modeling of wind energy conversion systems consists of four most important components. These are divided into following parts.

1. Wind turbine model.
2. Pitch control.
3. Drive Train.
4. Generator.

In modeling of the wind energy conversion system, pitch control and drive-train are the two components that are needed to be designed using the Matlab simulink software and the wind turbine model as well as the generator model is prebuilt in the software.

A. Pitch Control

Pitch control is the most important part in the design of the wind energy conversion system, it basically operates to control the speed of the moving rotor by changing the blade's pitch angle to safeguard the machine or the whole system. All the controllers that are to be tested are applied inside the pitch control.

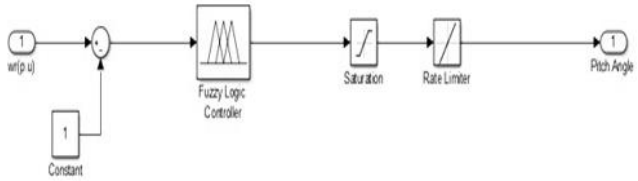

Figure1. Pitch Controller

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B.Drive Train.

The turbine's shaft speed is stepped up with the help of this. This is used in wind energy conversion system to make rotor speed constant and also work as a medium to transfer torque generated by the shaft to the generator.

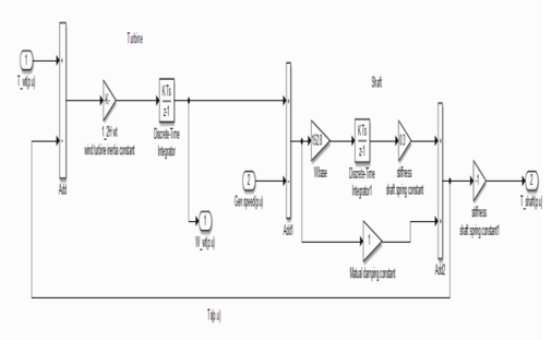
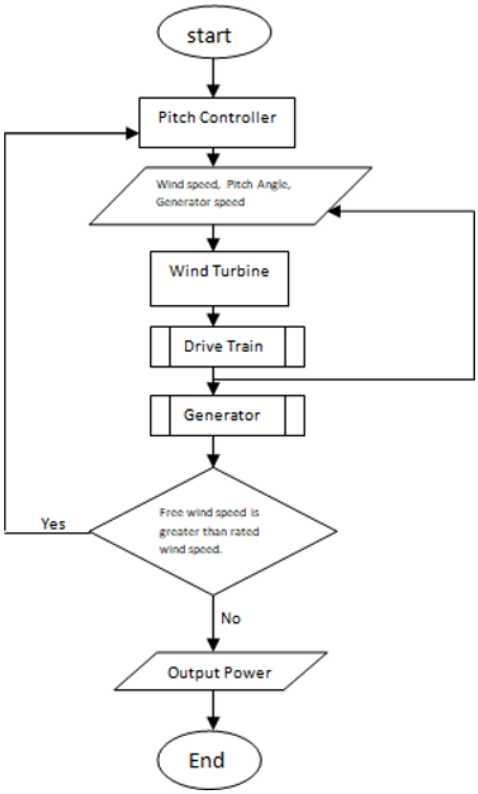


Figure2. Drive Train

C. Model Flowchart

Flowchart below illustrates the process of simulation of the WECS model.



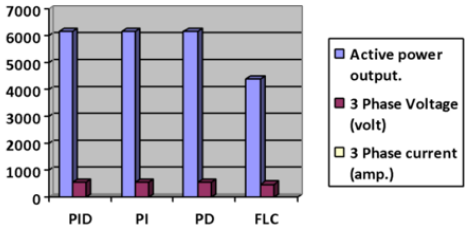
IV. RESULTS.

The comparison has been done on the wind energy conversion system by applying the controllers. The controllers that are applied are PID, PI, PD, FLC The comparative study gave the result that PD controller gave the maximum output that is the maximum output after applying the controllers on WECS model was extracted by the PD controller.

The values for P, I, D are for wind speed 12 m/sec are as follows p = 40.5, i = 15.09 and d = -6.612 for PID Controller, For PI Controller, P=31.67 and I=17.48, for PD Controller, P = 3270, D= 0. The table showing the comparison between the output active power and rotor speed is given below.

Table1. Comparison of controllers at wind speed of 12 m/ sec.

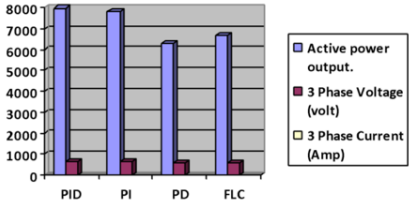
Wind speed = 12 m/sec	**PID**	**PI**	**PD**	**FLC**
Active power output (watt).	6187	6190	6169	4398
3 Phase Voltage (volt)	560	553	550	468
3 Phase current (amp.)	12.7	12.8	12.5	10.8



The values for P, I, D are for wind speed 15 m/sec are as follows p = 21.34, i = 2.862 and d = -10.89 for PID Controller, For PI Controller, P=16.56 and I=3.319, for PD Controller, P = 1128, D= 0. The table showing the comparison between the output active power and rotor speed is given below.

Table2. Comparison of controllers at wind speed of 15 m/ sec.

Wind speed = 15 m/sec	**PID**	**PI**	**PD**	**FLC**
Active power output (watt)	7987	7830	6288	6668
3 Phase Voltage (volt)	639	635	567	580
3 Phase Current (Amp)	14.7	14.5	13.1	13.4

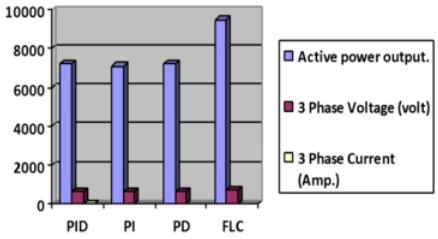


The values for P, I, D are for wind speed 17 m/sec are as follows p = 257.3, i = 9.099 and d = -163.9 for PID

Controller, For PI Controller, P=5388 and I=1.825e+04, for PD Controller, P = 2318, D= 0. The table showing the comparison between the output active power and rotor speed is given below.

Table3. Comparison of controllers at wind speed of 17 m/ sec.

Wind speed = 17 m/sec	**PID**	**PI**	**PD**	**FLC**
Active power output (watt).	7201	7109	7212	9484
3 Phase Voltage (volt)	602	598	600	678
3 Phase Current (Amp.)	14	13.8	13.9	15.7



V. CONCLUSION.

After modeling of WECS comprising of most important components, pitch control , drive train , generator and after the application of various controllers that are PID ,PI, PD and FLC on the wind energy conversion system model using Matlab simulink , the resultant output showed that at 12 m/ sec wind speed, PID controller is providing most stable output and PI Controller is giving more efficient power output compared to other controllers and at high wind speed FLC is giving the most efficient output.

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