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MODELLING, CONTROL AND SIMULATION OF MPPT FOR WIND ENERGY CONVERSION USING MATLAB/SIMULINK

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Abstract: **-This paper cover modeling, analysis, controland simulation of a maximum power point tracking (MPPT) for wind energy conversion. This wind energy conversion system (WECS) is grid connected and the amount of output electrical power generated from wind energy conversion system (WECS) is purely depends upon accuracy of the peak power tracked by the maximum power point tracking (MPPT) and PID controller used in WECS. A mathematical model of the system is present in this paper and it's also provides a review of MPPT controllers used for tracking maximum power from the WECS using (PMSG). In which controllers may be divided into three main controlling methods, namely power signal feedback (PSF)control, tip speed ratio (TSR) control and hill-climb search (HCS) control. The proposed system is simulated for some operations are used in this paper to illustrate the reliability control technique in WECS. The importance of MPPT in WECS, and the effectiveness of adopted control technique.**

Keywords:- MPPT, WECS, Simulation, Modelling, control techniques

I. INTRODUCTION

In the whole world the total installed capacity of wind energy has crossed 273 GW and expected to reach 350 GW in last of 2016. According to annual growth records for the last some years, in 2008 by 29%, in 2009 by 31%, and in 2012 by 35%.[1] The reduction in annual growth due to slowdown in the renewable energy markets of many countries. It was recognize, in 2010 by 25%, and2011 by 20% in a global decrease in wind energy system's installations in whole world. [2] The wind turbine includes two main parts: the electrical parts of the system and mechanical parts. Wind energy conversion system has many techniques for conversion wind energy in electrical energy. The important and most popular wind turbine current days is doubly fed induction generator based wind turbine due to its capability on variable speed operation. [3]

The main sub-systems in a wind system are the wind, the turbine and the farm. Fig.1General Structure of a wind Energy Conversion System Model. From left to right, the wind speed model provides the wind speed sequence whose parameters are chosen by the user according to the wind pattern of WECS. The equivalent wind speed for the individual turbines is calculated using both the wind speed and the wind farm characteristics of system.[4]the General structure of a wind Energy Conversion System Model shown in Figure:-1.

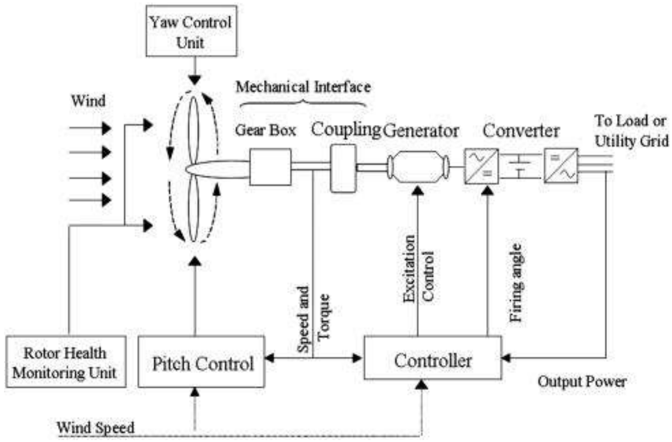

Figure: 1 General structure of a wind Energy Conversion System Model

The wind energy conversion system (WECS)is divided into following parts. [5]

1. Model of the wind energy.
2. Turbine model.
3. Shaft and gearbox model.
4. Generator model.
5. Control system model.

The mechanical parts used in wind turbine generator are three components. The generator produces an electro-mechanical link between turbine and output electrical power system. The control system controls the output power of the generator. In which, the concept of using the wind energy to obtain the electrical power can be

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represented by the following diagram. Figure:-1 General structure of a wind Energy Conversion System. The mechanical system of the wind energy conversion system (WECS) are working an important role in the conversion system of energy. Basically low speed shaft which is connected to wind turbine blades, and also the second speed shaft directly connected to the generator which is called the high speed shaft.[6]

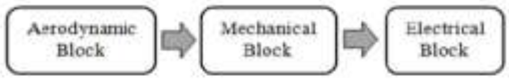

Figure:-2 Block Diagram Wind Energy Conversion System

The population of whole world is increasing and some studies predict a world population will be reached at 9 billion around 2040 in contrast to the 7 billion people living on the planet according to record on 30.9.20 12, total installed capacity of India is 2, 07,876 MW, out of which 20,162 MW is generated with the use of Renewable Energy sources viz., Wind energy, Hydro, Biomass, Solar etc.[7]

The improving solar power and also seen increase the load demand day per day. The Government of India has started the Jawaharlal Nehru National Solar Mission (JNNSM) to increase scale and drive down costs to grid parity. It is targeted to generate 22,000 MW by 2022.[8]

S. No.	Type of Power	Technology Used	Capacity (MW)
1		Wind	20,298.83
2		Small Hydro power	3,774.15
3	Grid Connected Power	Bagasse Cogeneration	2,512.88
4		Solar	2,208.36
5		Biomass	1,285.60
6	Grid Connected Power	Waste of Power	99.08
Sub Total (Grid Connected Power)			**30,177.9**
1		Bagasse Cogeneration	517.34
2		SPV System (1KW)	159.77
3		Biomass Gasifiers- Industrial	146.40
4		Waste of Power	119.63
5	Off Grid / Captive Power	Biomass Gasifiers- Rural	17.63
6		Water Mill/Micro Hydro	10.18
7		Aerogenrator/ Hybrid System	2.18
Sub Total (Off Grid /Captive Power)			**973.13**
TOTAL			**31,151.03**

Table: 1- Renewable Energy Installed Capacity in India

The wind energy conversion system (WECS) depends upon the accuracy and peak power which tracked by the MPPT controller of wind energy conversion system and control system of generator used.[9] The WECS fails to deliver any useful power to the load side or grid utility. As the wind speed increases above the cut in value, the wind turbine starts generating mechanical power in proportion to the cube of wind speed in region 2. [10]The power output increases till the rated wind speed (V_{rated}). At V_{rated} the system generates rated power. Beyond V_{rated} till cut out wind speed ($V_{cut-out}$) the power is regulated at rated power. Operation is shut down above $V_{cut-out}$ to avoid mechanical collapse of the blades[11].

II. MODELLING, SIMULATION AND CONTROL OF WECS

A. CUT IN SPEED

The exerted torque develop is insufficient for the wind on the turbine blades to make them rotate. However, as the speed increases, the wind turbine will begin to rotate and generate electrical power. The speed at which the turbine first starts to rotate and generate power is called the cut-in speed and is typically between 3 and 4 meters per second.[12]

B. CUT OUT SPEED

As the speed increases above the rate output wind speed, the forces on the turbine structure continue to rise and, at some point, there is a risk of damage to the rotor. [13] As a result, a braking system is employed to bring the rotor to a standstill. This is called the cut-out speed and is usually around 25 meters per second.

C. RATED OUTPUT WIND SPEED

The level of electrical output power rises rapidly. However, typically somewhere between 12 and 17 meters per second, this limit to the generator output is called the rated power output and the wind speed at which it is reached is called the rated output wind speed.[14].

Wind turbine is the system that harnesses of the kinetic energy of the wind for useful power

Wind energy conversion

Kinetic energy of wind is given by the following equation:

$$E_c = \frac{1}{2}mv^2 \qquad (3.1)$$

M = Air mass, V = wind speed, p = air density, S = covered surface of the turbine

Wind power is given by:

$$P_w = E_c = \frac{1}{2}mv^2 = \frac{1}{2}\rho S v^3 \qquad (3.2)$$

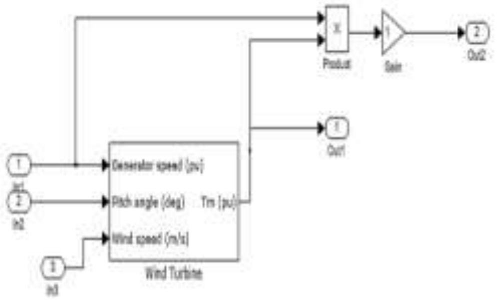

Figure:-3 Simulation model wind energy conversion system

The aerodynamic power of wind turbine is Pm is expressed as [12]

$$P_m = 0.5C_p(\lambda,\beta)\rho A v^3 \qquad (3.3)$$

Where ρ is the air density and A is the area swept by the blades

V = Wind speed

C_p= Power coefficient

β = Pitch angle

λ = Tip speed ratio

$$\lambda = \frac{R\,\omega_m}{V} (3.4)$$

ω_m= Rotor speed of the wind speed

The power coefficient of the wind turbines indicates

$$C_p(\lambda,\beta) = C_1\left(\frac{C_2}{\lambda_i} - C_3\beta - C_4\right)e^{-\frac{C_5}{\lambda_i}} + C_6\lambda (3.5)$$

$$\frac{1}{\lambda_i} = \left[\frac{1}{\lambda+0.089} - \frac{0.035}{\beta^2+1}\right] \qquad (3.6)$$

When pitch angle β = 0 and optimum speed ratio λ = 6.325, C_p has a highest value. C_p of the turbine is the divided into two terms wind power and function of the wind speed, rotational speed, and pitch angle. Output of the turbine is the torque applied to the generator shaft is per unit of the generator. [15]

The power coefficient C_p is a function of the tip speed ratio (λ), and the blade pitch angle (β) as shown in Fig. 4

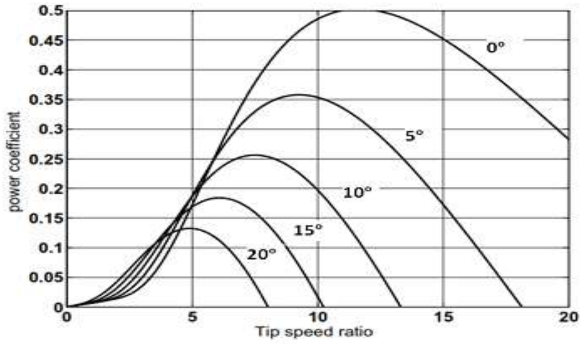

Figure:-4 Power coefficient Vs Tip Speed Ratio

PID CONTROLLER BASED PITCH ACTUATOR SYSTEM

The input, “beta_ref” is received as input which is passed through a saturation filter. The purpose of used the saturation filter is to limit the pitch input under the range of 3°to 90°which is the range of valid pitch angle values of the WECS. Next comes the gain block of the model is defining the proportional gain of the whole system, and the block named “Saturation 1” is also a saturation filter which defines the limiting values of pitching speed. The maximum and minimum permissible values of pitching speed in this system are 8 degrees per unit time and -8 degrees per unit time respectively[16].

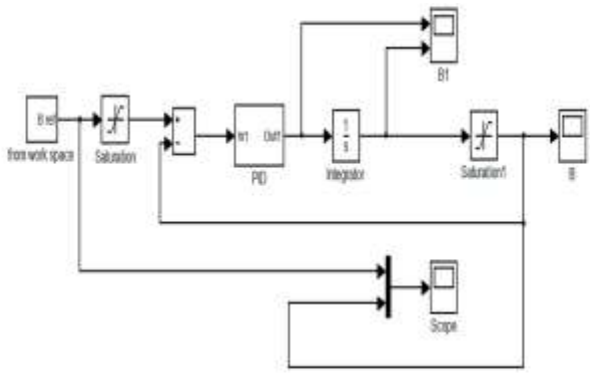

Figure:-5 Block Diagram with PID controller

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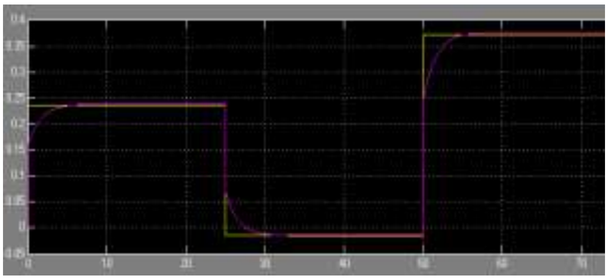
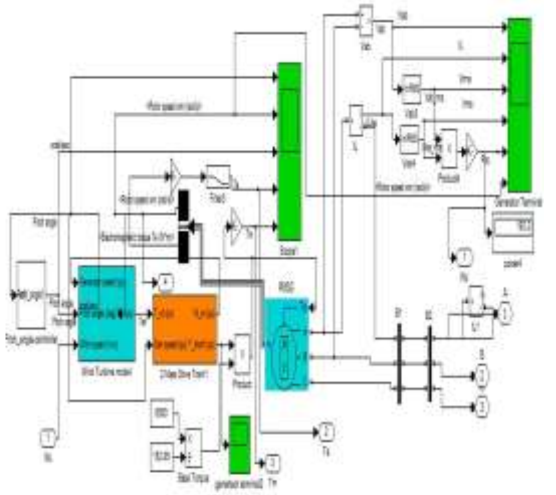


Figure:-6 Response of Simulink Model with PID Controller

III. IMULATION RESULT



IV.

Figure:-7 Simulation diagram for the wind generation system

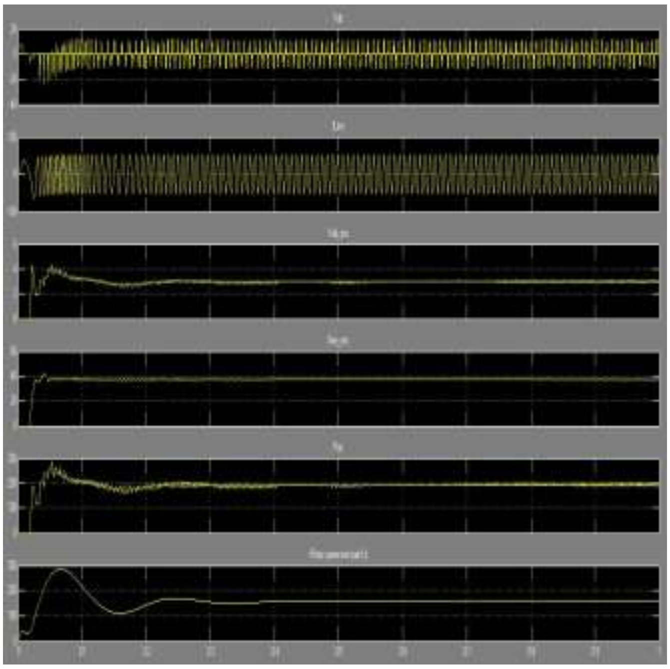


Figure: - 8 Simulation results for voltage, current, power and rotor speed in PMSG

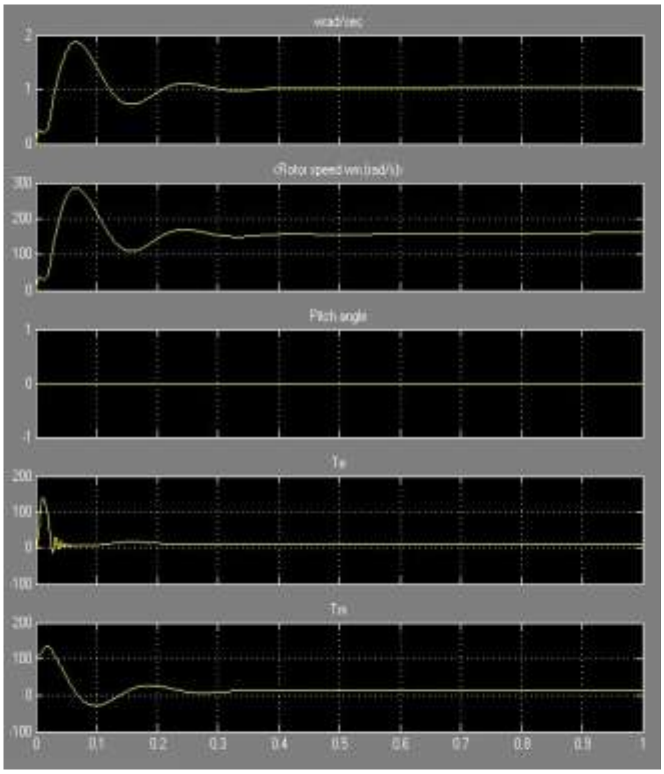


Figure: -9 Simulation results for wind speed, rotor speed, pitch angle and torque in wind turbine

V. CONCLUSIONS

This paper proposes a modelling, simulation and control strategy for wind energy conversion system. The new control strategy enables the DFIG and PID to continue the and implementation in electrical power production. A complete model for the study of PID controller based pitch actuator system for variable speed horizontal axis wind turbine is developed using MATLAB-Simulink.[17]The parameter used any block or subsystem of the model can be easily modified. The values of time response parameters of the pitch actuator system are observe by controlling action and the fine tuning of the controller parameters is performed. [18]
The maximum power is tracking on the base of the rotor speed of the wind generation system by using MPPT controller. The output of the MPPT is connected to the boost converter to adjust the duty cycle. The maximum power is achieved by controlling the duty cycle of the boost converter.[19]The simulation results represent that the proposed system shows the dynamic and steady state performances. The advantage of using PID controller is quick response. The

proposed wind generation system supplies maximum power to the grid with high efficiency and most reliability.[20]

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