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Pitch Angle Control through PI and PID Controller based for Wind Energy Conversion System

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Abstract*: The worldwide electrical energy consumption is growing day by day and also increasing the demand of power generation. So in addition into the electrical power system network for power production units a large number of renewable energy units is being combined. A wind energy generation system is the economical of all safe renewable energy sources and the environmentally clean in worldwide. The acceptance of variable speed generation systems the recent evolution of variable frequency drive and power semiconductors technology has been aided. Pitch angle control techniques is best factor to improve the efficiency as well as protection of the wind turbine blade. Therefore, presented in the work a comprehensive model of permanent magnet machines in wind turbine system. Modelling and simulation permanent magnet machines with wind turbine system of PI and PID controller based pitch angle control figuring performance is done by using MATLAB software. The significant result of these controller performance is being compared and also shown with validate approach with the existing survey.

Keywords: MATLAB, pitch angle, PMSM, PI and PID controller.

I. INTRODUCTION

In both the motoring and generating modes used permanent magnet synchronous machines (PMSM) are a popular class of linear and rotating electric machines. For applications where low initial cost and simplicity of structure PMSM have been used for primary importance from many years. More recently, for more demanding applications PMSM have been applied, above all as the result of the improvement of permanent magnet characteristics and the accessibility of low-cost power electronic control strategies [1], [2]. Permanent magnets energy converters using in a various configurations and are defined by such factors as generator, motor, stepper motor, alternator, actuator, tachometer, linear motor, brushless dc motor, control motor, transducer, and many others. Another side the concept of pitch control of rotor blade emerged and its basic features has to run self-aerodynamic parameters through a combination of actuators, controllers and sensors those provide us higher capacity of load control. Due to various advantages over traditional system of pitch control with flexibility, fast response, small size and positive performance. So in this work contrast is modelling and simulation permanent magnet machines with wind turbine system of PI and PID controller based pitch angle control figuring performance is done in MATLAB software.

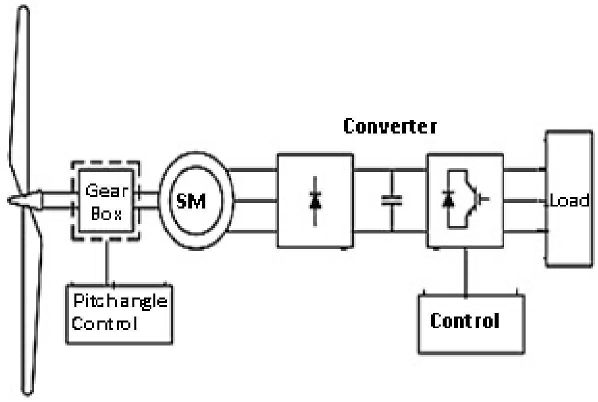

Fig. 1 Block diagram of adopted Wind Energy Conversion Systems.

II. AERODYNAMIC POWER CONTROL FOR WIND TURBINES

The wind turbines need mechanical power control to the supplied at the generator, whenever an adapted generator extents by the rated power [3]. When for wind turbine generator extents by the rated power at occurrence of 15 m/s as per maximum speed is usually 25 m/s accordingly. This is valid because for a wind turbine, and that can be controlled through three altered methods called stall, pitch and active stall a combination of both. The pitch angle by reducing the angle occurred of the blades is controlled to keep the power of wind generator at rated power [4]. Other side no moving parts in the stall-controlled turbine blades and to make them stall the challenge is in the construction gradually and turbine blades to avoid vibration. By changing the pitch angle to be on the stalling will be reutilized quickly torque fluctuations from the wind. The wind turbine power captured is given by.

$$P_m = P_w \times C \quad (1)$$

III. WIND TURBINE CONTROLLER

An augmentation of multi-processor controller (MPC) such the name of this controller is the multi-processor controller according to the wind turbine. These controller controls and monitors all parameters w.r.t. the wind turbine, the turbine is optimal at any wind speed in command to ensure that the performance.

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At an operating section, current operation data is showed error if supervision detects an error then the control will stop the turbine. [5], [6].

The MPC is distributed in to two portions:

1. Top side controller and
2. Ground level controller

Top side controller operates the jobs in the nacelle, such as power, pitch, speed control, internal temperature control and yawing. Ground level controller operates in cut in speed and cut-out speed of the wind generator, of current and voltage measurement and the capacitors [7], [8].

IV. DATA COLLECTION

All performance data of wind turbine collected by the MPC continuously like wind speed, hydraulic pressure, pitch, rotor and generator speed, temperature, power and energy production etc [9], [10].

Pitch control is the wind turbine blades drive according to their specific longitudinal axis. If nearly abnormalities or getting errors, the data is kept in a LOG and/or an ALARM LOG, to analyze errors occurred in the wind turbine to possible. For self-starting, speed control of rotor and optimization of power generation we need the pitch control system [11], [12]. The pitch control system changes the pitch angle as shown in figure 2. The pitch control system contains in a two way first one is a linear feedback path Δβ and second one is a nonlinear feed forward path β0 [13].

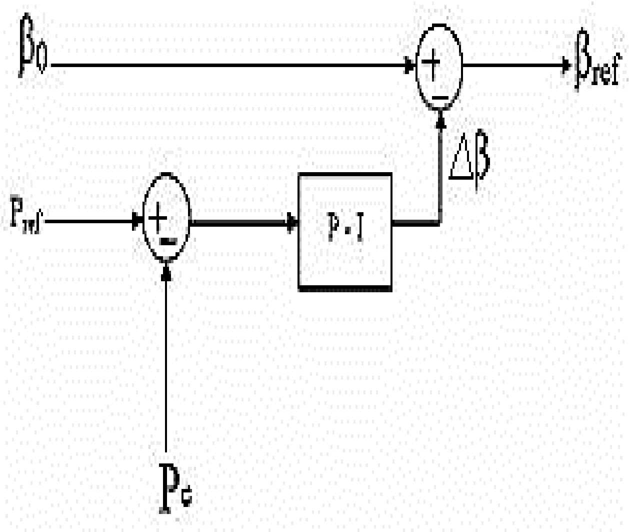

Fig. 2 Pitch angle reference generators

$$\beta_0 = \sqrt{\frac{1}{0.022}\gamma - 5.6 - \frac{2P_{ref}e^{0.17\gamma}}{P_w}} \qquad (2)$$

There are two types of wind energy generators (WEG) stall-regulated control and pitch angle control. Over the blade profile is missing and not as much of torque developed on the shaft of the rotor to restrictive the output power use stall-regulated WEG. Other hand by using pitch regulated WEG when speed increases or decreases the power output remains constant.

On the other hand, the forward path take on that all the parameters are at ideal condition and doesn't countered losses in the system. When countered losses in the system feedback path given signal for decreasing the pitch angle to increase the power according to the desired output power. By using the Zeigler-Nicholas rules we adapt PID (Proportional integration and differentiation) controllers designed the P-I controller (Proportional integration) for the system [14], [15].

The Pitch controlled WEG has the subsequent added advantages.

- The pitch control mechanism allows the blades to be adjusted to a position that can stop and resume the rotor at any wind direction.
- Active Control: For successful control, the Pitch method is beneficial, from which nominal strength can still be obtained. Install governed, however, power curve can only be adjusted by making a permanent adjustment in the angle of the blade.
- Speed: Speed will be tracked before the grid connects to the WEG. The pitch control system for a longer time makes rotating at the correct pace before linking to the grid [16].
- Low wind speeds: Also at lower speeds, the maximum torque of the Pitch-Controlled WEG is obtained and the rotor begins, while the higher wind speed of the Stall Controlled WEG is needed because of the configuration. This in turn will lead the electrical components to decrease in lifespan.
- Power: At locations with a poor grid, power can be reduced. The WEG can be effectively controlled by the use of pitch control system and no need to adjust the configuration of the WEG to deliver less rated power.
- Pitch Control System: The pitch control mechanism is not greatly influenced by the increase in temperature and air density, given the position WEG's at several altitudes above sea-level. The maximum power output can often be accomplished in a WEG with pitch-controlled, although it is low in a stall-controlled WEG as when the blades are dusty or temperature rises.
- Calculation of Rotor and Blade Loads: The blades always experience laminar flow across the turbulent and profile in the case of Pitch-Regulated WEG's, no influence occurred by chaotic flow. a more correct manner determined of WEG loads in a Pitch Controlled WEG.

V. MATLAB® /SIMULINK MODEL OF PROPOSED SYSTEM

Fig.3 shows the whole system; of PMSM to wind turbine system is invented in the work. In this system we used PI and PID controller for pitch angle control for WECS.

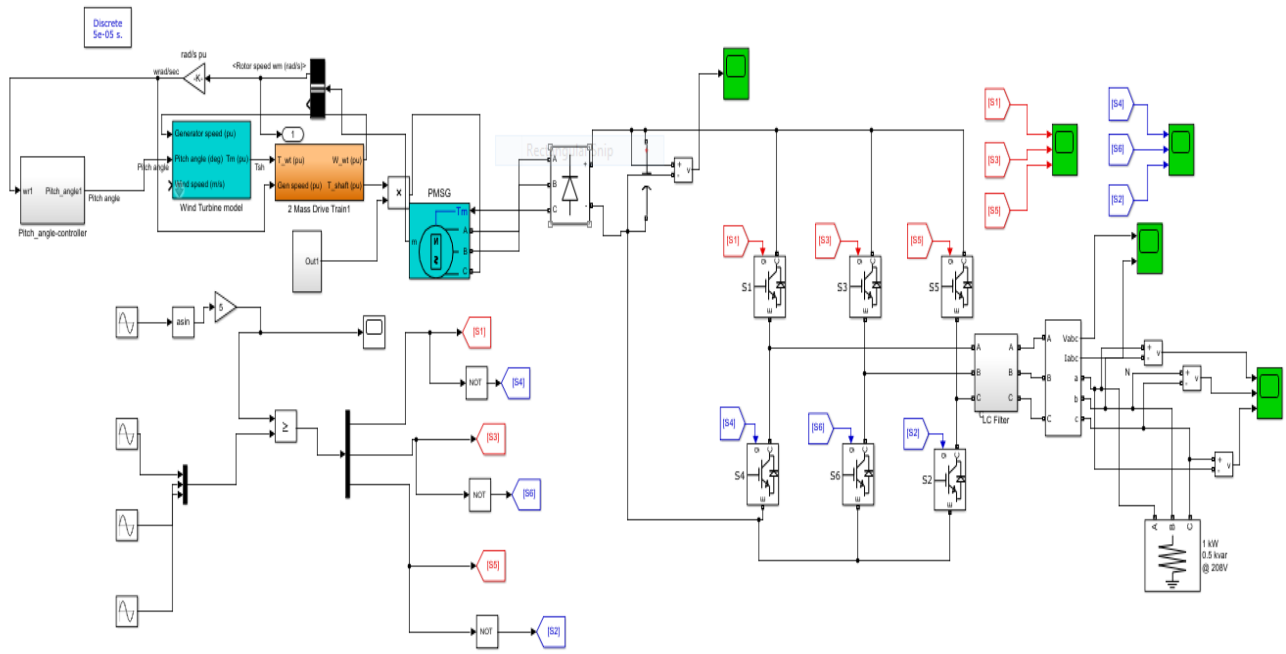

Fig.3 MATLAB Simulink model of WECS

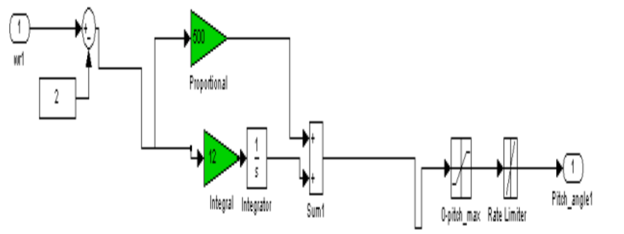

Fig.4 MATLAB model of PI controller based pitch angle control with for WECS

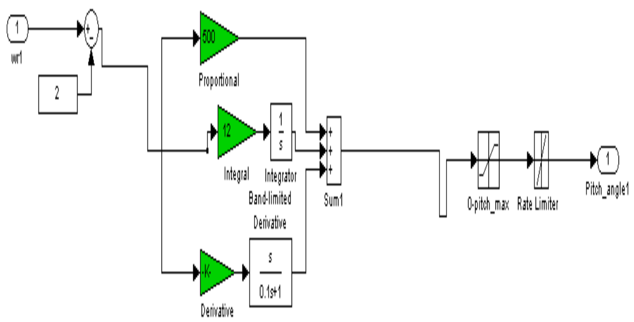

Fig.5 MATLAB model of pitch angle control with PID controller for WECS

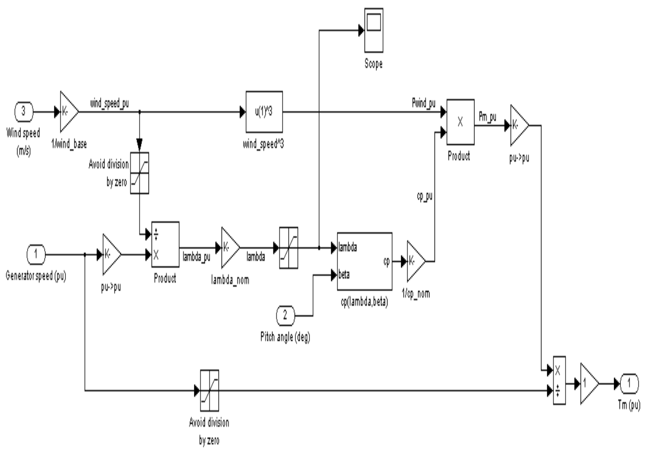

Fig.6 MATLAB Simulink model of wind turbine systems

VI. SIMULATION RESULTS AND ANALYSIS

PI and PID controller based pitch angle control for Wind Energy Conversion System. Proposed system is connected in the standalone load. In this system connected to rectifier and inverter for power electronics circuit to control the WECS for higher efficiency. The simulation results we discuss to case first one pitch angle controlled by PI controller and second one PID controller w.r.t. power, voltage, current and total harmonic distortion.

CASE I.PI Controller Based

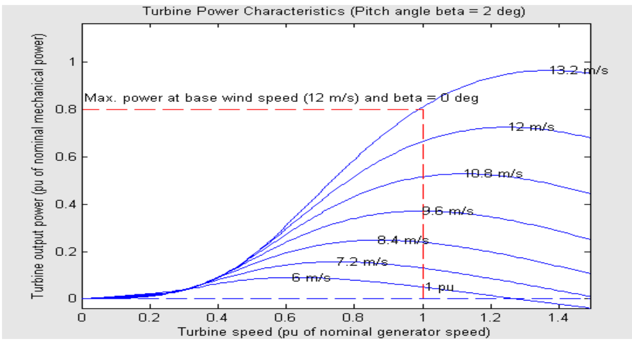

Fig.7 Turbine power characteristics of pitch angle control with PI controller for WECS

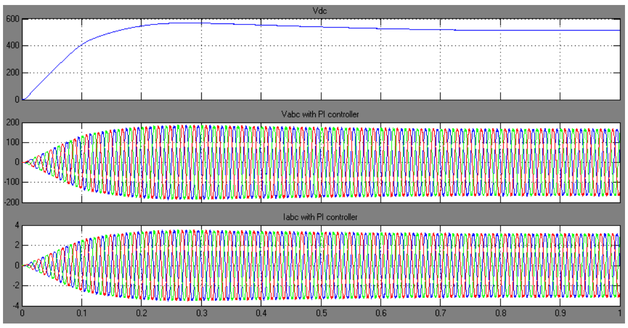

Fig.8 Vdc, Vabc and Iabc waveform of PI controller based pitch angle control for WECS

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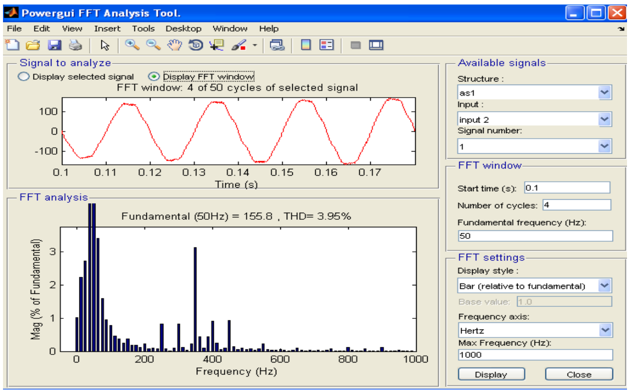

Fig.9 THD of voltage waveform of pitch angle control with PI controller for wind energy conversion systems (THD=3.95%)

CASE II.PID Controller Based

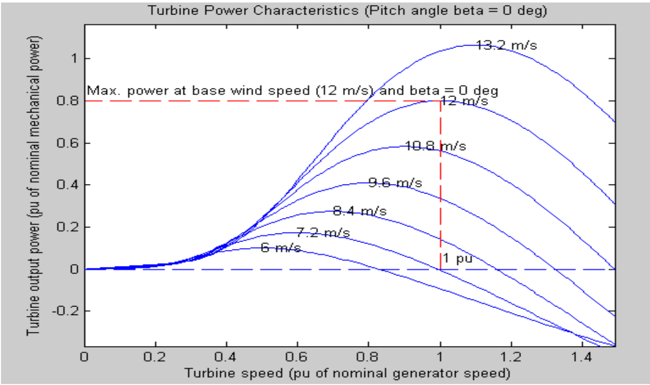

Fig.10 Turbine power characteristics of pitch angle control with PID controller for WECS

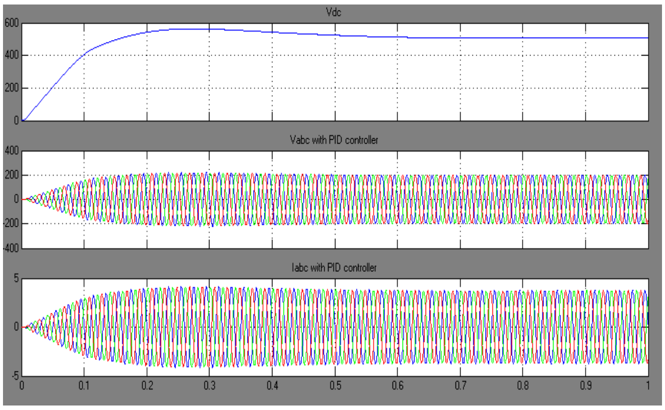

Fig.11 Vdc,Vabc and Iabc waveform of pitch angle control with PID controller for WECS

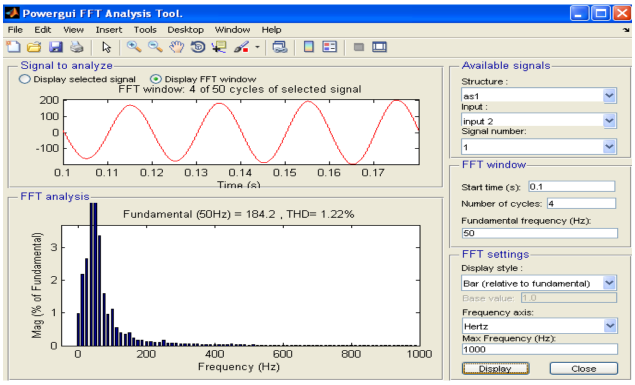

Fig.12 THD of voltage waveform of pitch angle control with PID controller for WECS (THD=1.22%)

VII. CONCLUSIONS

In this work we present an analysis and MATLAB® simulation of a PI and PID controller based pitch angle control for wind energy conversion systems. These system is used permanent magnet synchronous machines to wind energy conversion systems. We chose two cased for pitch angle control PI controller and PID controller to improve the efficiency as well as protection of the wind turbine blade. The performance of a PI controlled based pitch angle control for wind energy conversion systems verified. Order of harmonics of the voltage waveform (THD=3.95%). And PID controller based reduced to (THD=1.22%).Discussed MATLAB simulation results of both case of the proposed system.

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ABBREVIATIONS

WECS	Wind Energy Conversion System
PI	Proportional Integration
PID	Proportional Integration and Differentiation
PMSM	Permanent Magnet Synchronous Machines
MPC	Multi-processor Controller
WEG	Wind Energy Generation
SM	Synchronous Motor
THD	Total Harmonic Distortion

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