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Analysis of the Grid Connected Wind Energy System using MATLAB/Simulink

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ABSTRACT: Renewable energy has become one of the most important and promising sources of energy generation in recent years which supply's more transmission capacity and better means of maintaining system reliability and effiency. In the fast growing electricity supply industry and open access market for electricity worldwide, renewable sources are getting added into the grid system. The evolution of technology related to wind systems industry leaded to the development of a generation of variable speed wind turbines that present many advantages compared to the fixed speed wind turbines. This project consists of wind-turbine-driven PMSG, connected with the Grid power system. Permanent Magnet Synchronous Generator (PMSG) is being used due to its high efficiency. In this paper, Simulation of wind generation is being done with grid system.

KEYWORDS: -Modeling, PMSG, Wind Turbine, Inverter, SVPWM, MATLAB

I. INTRODUCTION

The electric power generation from non-conventional energy sources, such as wind, is increasingly attracting interest in recent years because of environmental problem and shortage of other energy source in the near future. Moreover increased and concentrated penetration of wind energy into electrical power systems has made the latter more valuable and dependent on the wind energy production [1]. The continuous trend of having high penetration of wind power, in recent years, has made it necessary to introduce new practices, viz grid systems are being examined to ensure that wind turbines would have more effiency for control of voltage and frequency and also to remain connected to the main network following voltage sag. Renewable energy sources not providing the enhanced greenhouse effect, particularly wind power generation, is becoming a vital component of the total grid power generation. wind turbine produces a continuous variable and stabilized output power during normal operations. The power changes and fluctuations are mainly caused by the effects like turbulence, wind shear, and tower-shadow and control system in the power system. So, whole network system is responsible for these floatation's. The power quality problems can be checked with wind generation, transmission and distribution power networks, like voltage sag, swells, flickers, harmonics etc. Distribution network is being disturbed with the wind generator. One method is to use induction generator which is directly connected to the grid power system. The induction generator has great advantages of cost effectiveness and heftiness [2]. Permanent magnet synchronous generator (PMSG) is used for wind power generating system because of its many advantages such as better effiency, lower maintenance, and reliability. The PM machines have many advantages which include higher reliability, higher efficiency and energy yield, Lower maintenance cost.

II. WIND TURBINE MODELING

The wind turbine consists of classic three-bladed horizontal-axis , wind turbine system with the corresponding pitch controller. The output mechanical power is given by the equation [3]

$$P_m = C_p(\beta,\lambda)\ \rho A/\ 2(V_w)^3$$

Where Pm = Turbine mechanical output power
C_p= Performance coefficient of turbine
ρ= Air density (Kg/m^3),
λ= speed ratio

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A= swept area of turbine
β= blade pitch angle
V_w= wind speed (m/s)

The power coefficient Cp is a nonlinear function of the blade pitch angle β and the tip-speed ratio λ as given by [3]

$$\lambda = (R\omega_m/v_w)$$

Where, ω_m - Angular speed of the turbine rotor
R - Radius of the turbine blades

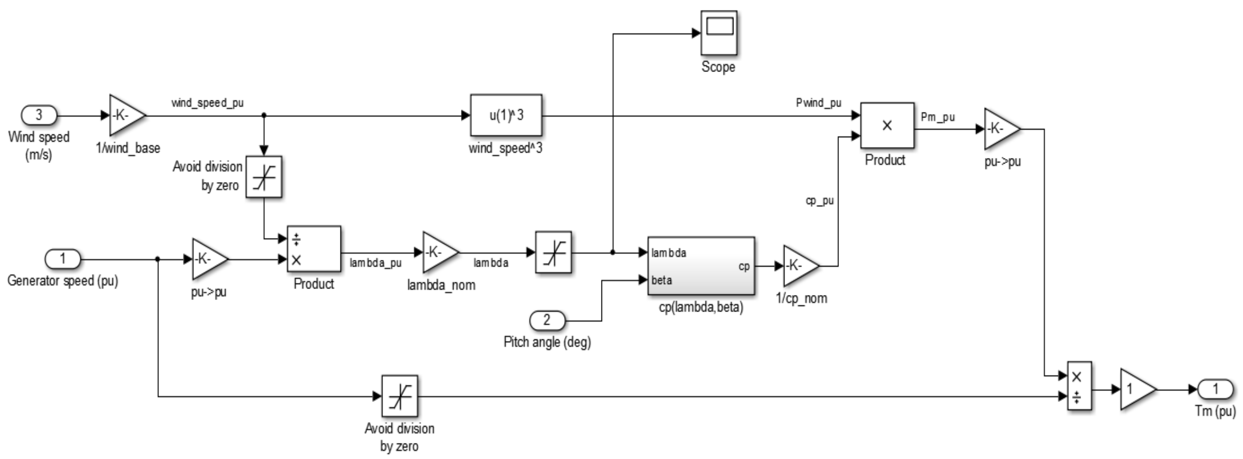

Figure 1 Simulink of Wind turbine Modeling

III. PITCH CONTROLLER

Pitch control system is for each blade in a turbine. Each pitch control system is a servo loop which will make the pitch follow a given reference as quickly as possible and with sufficient damping. The pitch controller is a non-linear controller which compensates for the dead band and the limitations in the proportional valve. When the wind velocities are higher than rated, the maximum energy captured must be limited using pitch control by modifying β.

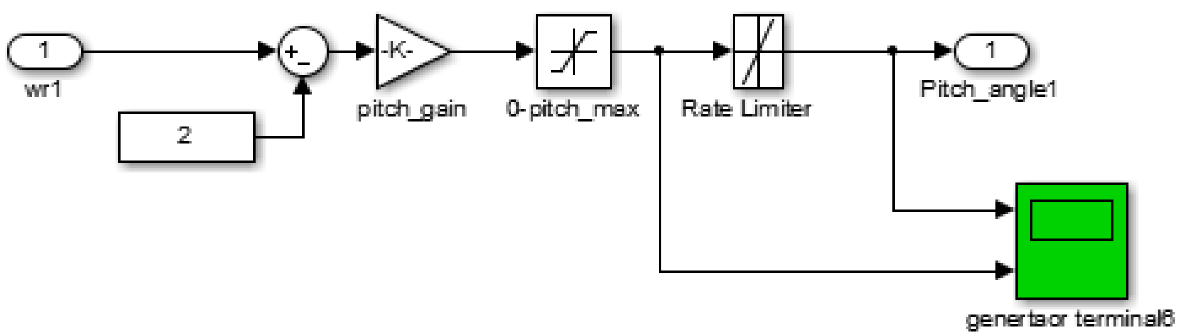

Figure 2 Simulink of Pitch angle Controller

IV. TWO- MASSE MODEL

This Model shows the combination of wind turbine and shaft side. The differential equations are representing its mechanical dynamics which are given below

$$\mathbf{2H_t\, dw_t /dt = T_m - T_{sh}}$$
$$\mathbf{1/w_{elb} * d\theta_{tw}/dt = w_t - w_r}$$
$$\mathbf{2H_g dw_r/dt = T_{sh} - T_g}$$

Where H_t = inertia constant of the turbine,
H_g= inertia Constant of the PMSG,
θ_{tw} = shaft twist angle,
w_t = Angular speed of the wind turbine in p.u.
w_r = rotor speed of the PMSG in p.u.
w_{elb} = electrical base speed

The Shaft torque T_{sh} is

$$\mathbf{T_{sh} = K_{sh}\, \theta_{tw} + D_t\, d\theta_{tw}/dt}$$

Where Ksh = shaft stiffness
D_t = damping coefficient.
The simulink model is shown below.

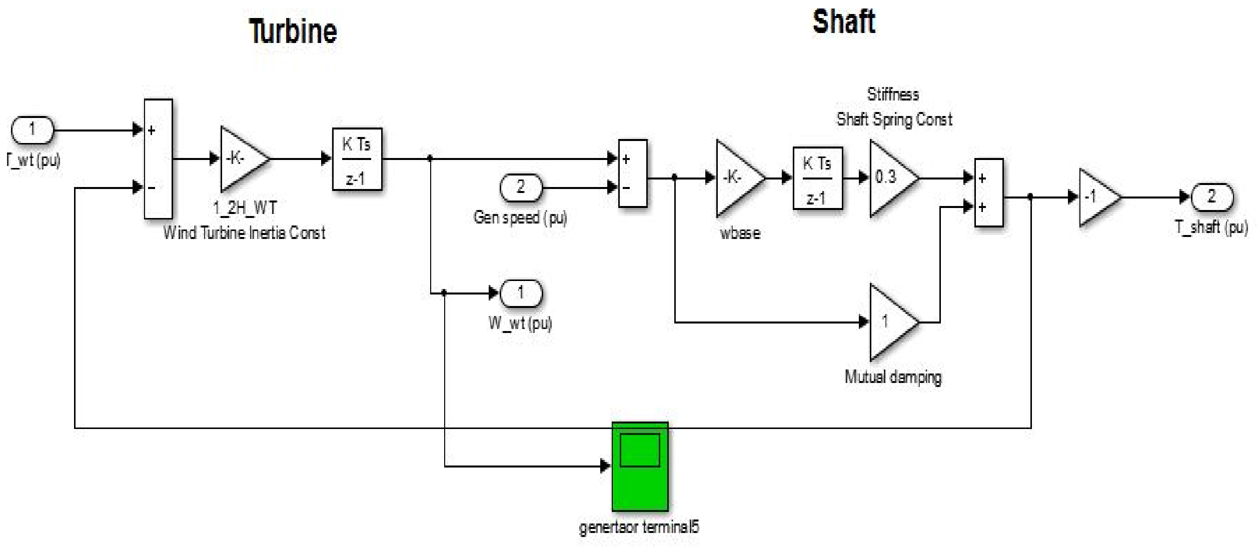

Figure 3 shows simulink model of two- masse Model

IV. Permanent Magnet Synchronous Machine

The permanent magnet synchronous machine works as a generator .The second order state space model is represented with electrical and mechanical parts of this machine. The sinusoidal model assumes that the flux established by the permanent magnet is sinusoidal which furthur implies that Emf is also sinusoidal. These equations are represented in rotor reference frame .All quantities in the rotor reference frame referred to the stator.

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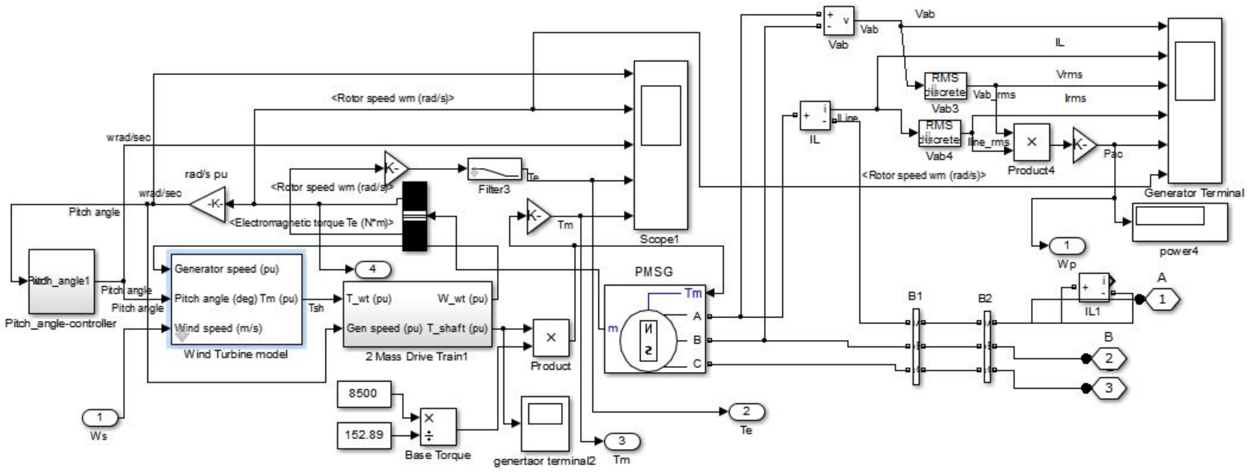

Figure 4 showing subsystems connected with PMSG.

V. SIMULINK MODEL OF WIND-GRID CONNECTED SYSTEM

This is the Simulink diagram for wind turbine connected with the grid system.

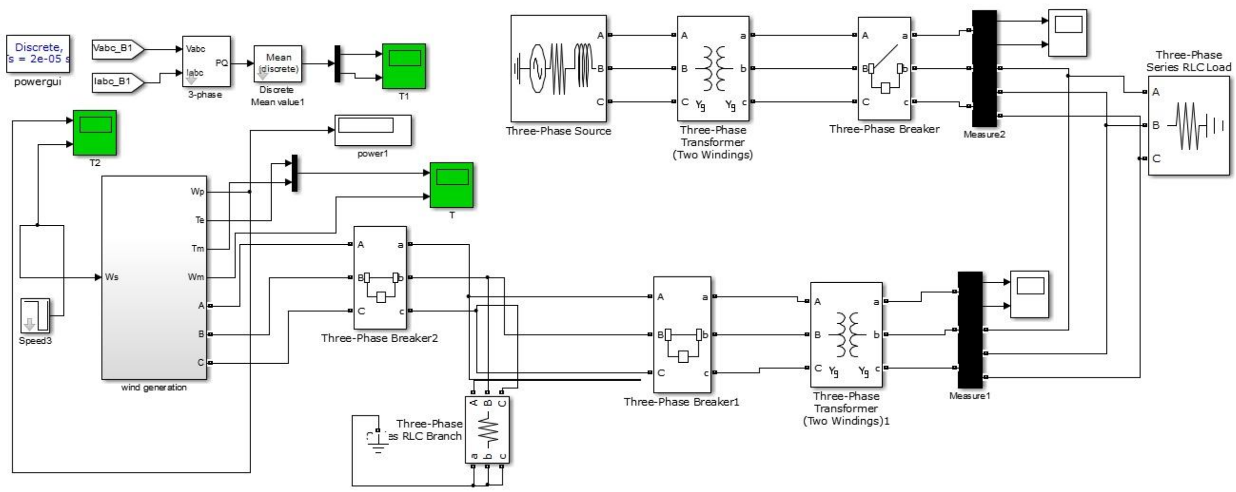

Figure 5 Simulink Model of wind-Grid Connected system

VI. SIMULINK RESULTS

The output of wind power energy system is shown below in which the phase voltages, line currents, RMS value of phase currents, active power and rotor speed is shown below.

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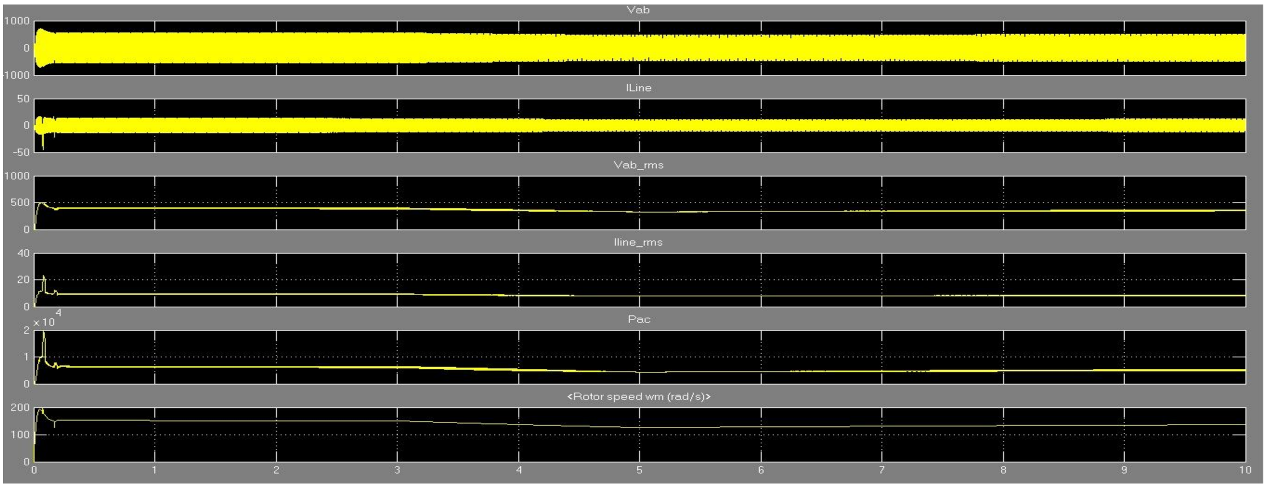

Figure 6 shows (1) phase voltages (2) line currents (3) RMS value of phase voltage (4) RMS value of phase currents (5) active power (6) rotor speed for wind speed 15 m/sec.

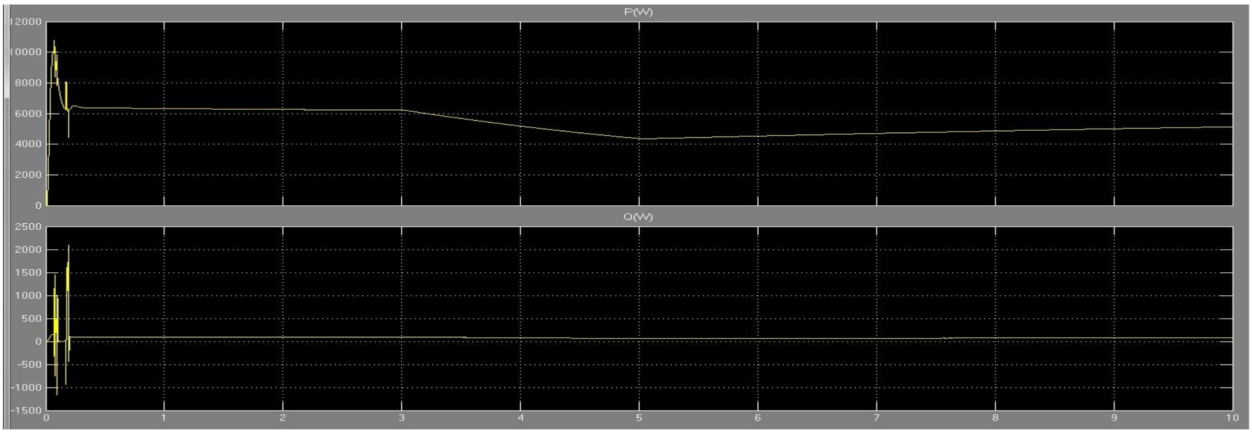

Figure 7 shows the Active and Reactive Power

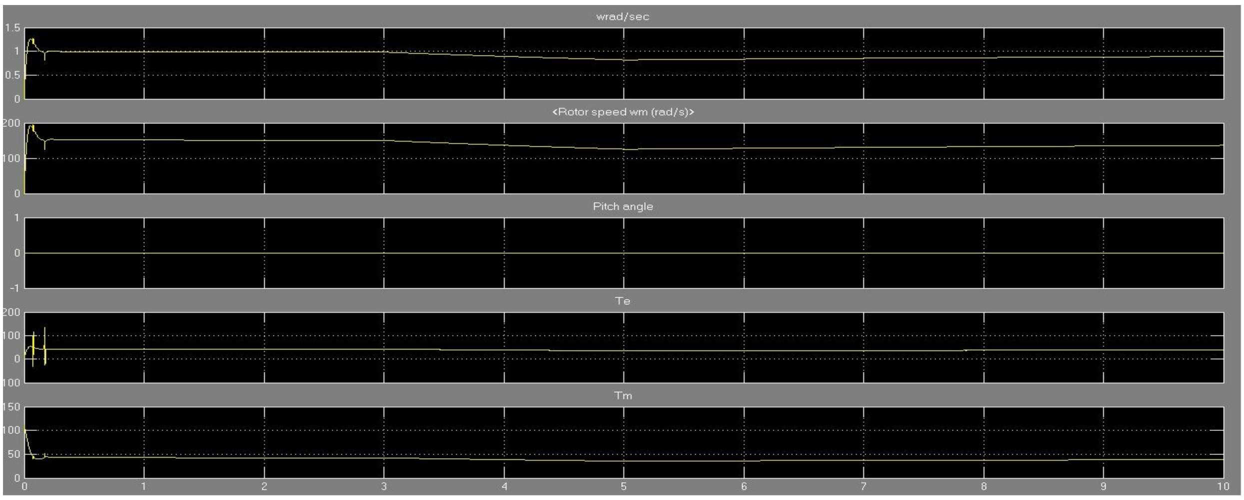

Figure 8 shows (1) wind speed (2) rotor speed (3) pitch angle (4) Electrical Torque (5) Mechanical Torque

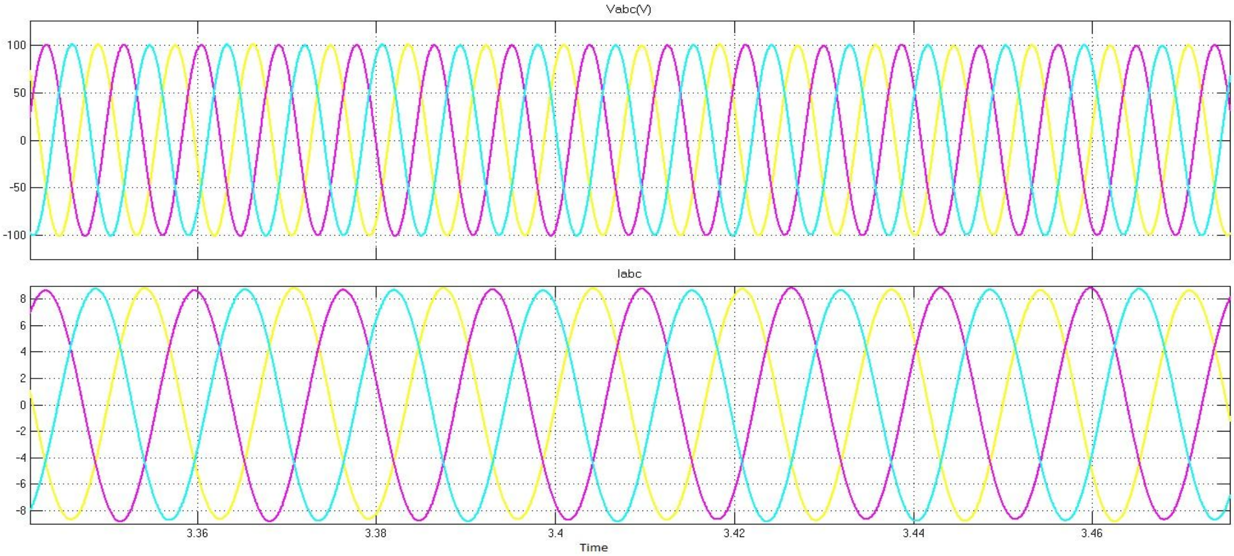

Figure 9 shows waveform of constant voltage and current across the grid in constant wind speed 15m/s.

VII. CONCLUSION

In this paper, we have simulated wind energy system connected with the grid is being analyzed with the help of MATLAB/Simulink.. The wind speed, rotor speed and torque being controlled to provide the active and reactive power supply. The output of this model provides us balanced ac supply. The reactive power is controlled and regulated which is connected to the grid system, shown above in waveform.

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Dr. Jafar Salamat Khan (born 19th February 1950 He is an professor in department of electrical & electronics with Al-Falah University Faridabad, Haryana. . He received his B.Sc. Engg. (Elect.) ,M.Sc. Engg. (Elect.) and Ph.D from Aligarh Muslim University, Aligarh in 1971, 1974 and 1979 respectively. He worked with M/s. Engineering Projects (India) Ltd, New Delhi, a Govt. of India Enterprise, from 1977 to 1982. He joined Council of Scientific & Industrial Research (CSIR) in 1982 as a Scientist and superannuated from CSIR as Advisor in February 2010. He has rich and wide experience in Project Engineering, Project Marketing, R&D Planning, Technology Marketing, and Commercialization of indigenous technology developed through R&D. He has published more than 30 papers in National & International journal. He joined Al-Falah University in March - 2010 as Professor in Electrical & Electronics Engineering Department.