Stability Analysis of DFIG Wind Power System Using PI Controller with static feedback

Dipesh Kumar Sharma, S. P. Shukla

Abstract: ***When the wind electricity is associated with an electric grid affects power quality. Power quality issues like active power, reactive power, change in voltage, flicker, harmonics, and electric behavior of switching operations has to measure. Most of the wing power era system used the doubly fed induction generator, due to its benefit of making sure a variable rotation and it can run above the synchronous value. DFIG prevent damage of the wind turbine mechanism whet it is used more than the rated speed. In the present work, with the help of PI controller scheme will get the enhancement behavior of a DFIG.***

***Index Terms*: Power quality, wind generator, double fed induction generator, PI controller.**

I. INTRODUCTION

The thriving need of electrical energy and need to preserve the nature due to reduction in fossil fuels and increased pollution of problems peoples are interested in sustainable development by the use of source of renewable energy which becoming very essential for electrical power generation system. By the comparison of all renewable energy sources one of the most economical renewable source is wind energy system [1].

Since the DFIG has many advantages so most of the generating plant recently used it [2], like it can work on different speed mode, provide almost constant frequency [3], reduced mechanical stresses [4]. The employment of doubly fed induction generator for the generation of additional power [5].

Most of the countries have wind energy conversion system is a very popular non-conventional power generation technology [6]. In wind energy generation system previously used generators are induction generator and synchronous generator. DFIG is very good alternative for variable and unpredictable wind speed [10].

The doubly fed induction generator base wing generation system is shown in fig. 1[7-8]. DFIG consisting an induction generator (wound rotor type) and a conversion system means from AC to Dc or from DC to AC and PWM voltage source converter with IGBT switching. Stator winding connected directly to the grid with constant frequency 50 Hz

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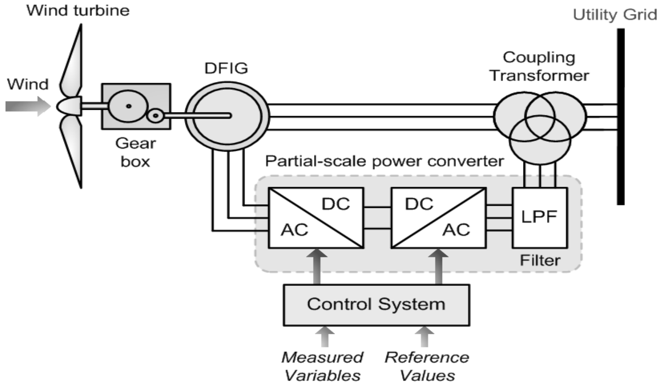

Fig.1. DFIG-based wind energy conversion system scheme [2]

II. MATHEMATICAL MODEL OF DOUBLY FED INDUCTION GENERATOR

Stator and rotor equations are given as follows,

$$V_{sd} = R_s i_{sd} + \frac{d\Psi_{sd}}{dt} - \omega_d \Psi_{sq} \quad (1)$$

$$V_{sq} = R_s i_{sq} + \frac{d\Psi_{sq}}{dt} + \omega_s \Psi_{sd} \quad (2)$$

$$V_{rd} = R_r i_{rd} + \frac{d\Psi_{rd}}{dt} - (\omega_s - \omega)\Psi_{rq} \quad (3)$$

$$V_{rq} = R_r i_{rq} + \frac{d\Psi_{rq}}{dt} - (\omega_s - \omega)\Psi_{rd} \quad (4)$$

Where,

$$\Psi_{sd} = L_s i_{sd} + L_m i_{rd} \quad (5)$$

$$\Psi_{sq} = L_s i_{sq} + L_m i_{rq} \quad (6)$$

$$\Psi_{rd} = L_r i_{rd} + L_m i_{sd} \quad (7)$$

$$\Psi_{rq} = L_r i_{rq} + L_m i_{sq} \quad (8)$$

These are the voltage as well as flux equations in terms of resistance, inductance currents.

ω_s represents the angular velocity at synchronous speed. Rotor angular velocity is given as

$$\omega_r = \omega_s - \omega \quad (9)$$

The torque is given as follows,

$$T_m = n(\Psi_{sq} i_{rd} - \Psi_{sd} i_{rq}) \quad (10)$$

Where n is the number of poles.

The active power is given as

$$P_s = V_{sd} i_{sd} + V_{sq} i_{sq} \quad (11)$$

Reactive power is given as

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$$P_s = V_{sq}\, i_{sq} - V_{sd}\, i_{sd} \qquad (12)$$

Using the equation (5) & (6), we get stator currents for d-q axis, as follows

$$i_{sd} = -\frac{L_m}{L_s} i_{rd} + \frac{V_{sq}}{L_s \omega_s} \qquad (13)$$

$$i_{sq} = -\frac{L_m}{L_s} i_{rq} \qquad (14)$$

Now using stator current we formulate the equation (11) & (12) again as foloows,

$$P_s = -\frac{L_m}{L_s} i_{rq} V_{sq} \qquad (15)$$

$$Q_s = -\frac{L_m}{L_s} i_{rd} V_{sq} + \frac{V_{sq}^2}{L_s \omega_s} \qquad (16)$$

Now by using equations (7) & (8), we can obtain the value of flux, as give below

$$\Psi_{rd} = L_r.\sigma.i_{rd} + L_m \frac{V_{sq}}{L_s \omega_s} \qquad (17)$$

$$\Psi_{rq} = L_r.\sigma.i_{rq} \qquad (18)$$

Now substituting the value of equation(17) & (18) on equation (3) & (4) we get

$$V_{rd} = R_r i_{rd} + L_r.\sigma \frac{d i_{rd}}{dt} - \omega_r.L_r.\sigma.i_{rq} \qquad (19)$$

$$V_{rq} = R_r i_{rq} + L_r.\sigma \frac{d i_{rq}}{dt} + \omega_r.L_r.\sigma.i_{rd} + \omega_r L_m \frac{V_{sq}}{L_s \omega_s} \qquad (20)$$

$$\sigma = 1 - \frac{L_m^2}{L_s L_r} \qquad (21)$$

By using equations (15), (16), (19) and (20), obtain the simplified model of the DFIG presented in figure 2.

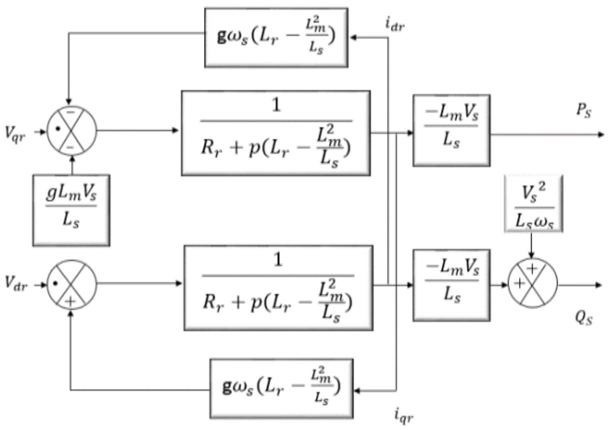

Fig.2. DFIG

III. PI Controller Design

For the speed control of the system many techniques are used, out of them PI controller is very versatile and used for speed control of motor and generator at power plants. In the present work we use the PI controller with static feedback control. It help us stable operation of the system, as shown in figure 3[11].

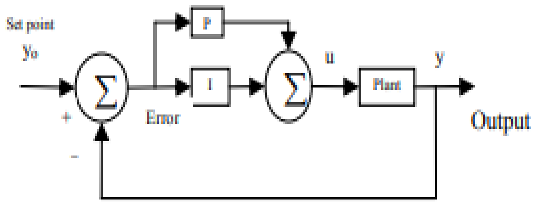

Fig. 3. PI controller with static feedback.

Output of PI controller is given as,

$$u = K_p Y_o + K_I \int Y_0\, dt \qquad (22)$$

Where Kp is the proportional constant and K_I is Integral constant.
Aslo equation (22) can be written as

$$u = [K_p \quad K_I][Y_0 \int Y_0]T \qquad (23)$$

Output is given as

$$Y = [Y_0 \int Y_0]T \qquad (24)$$

PI controller is describe as

$$G_C = [K_P \qquad K_I] \qquad (25)$$

Table 1: The PI parameters

PI parameters	Proportional constant (K_P)	Integral Constant (K_I)
Value taken	0.724	5.675

IV. Methodology & Result

Wing turbine simulation model is shown in figure.4

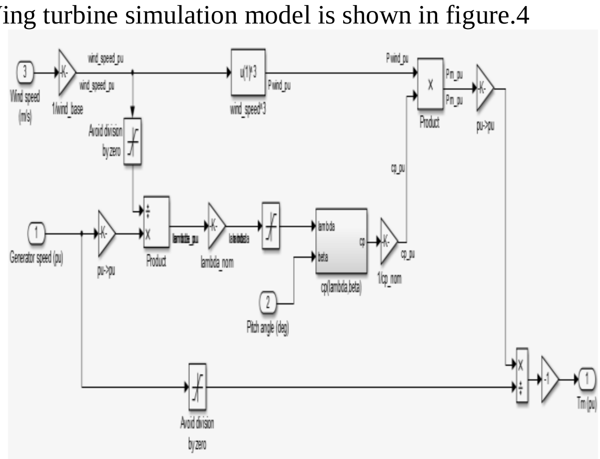

Fig.4 Simulink model of Wind turbine

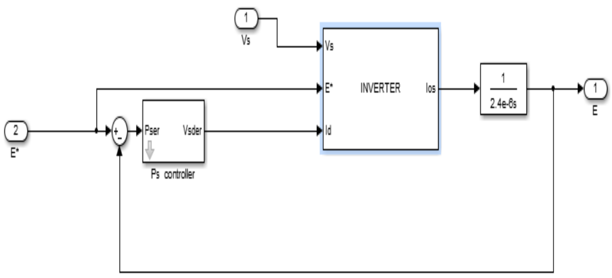

Fig.5. Front End converter

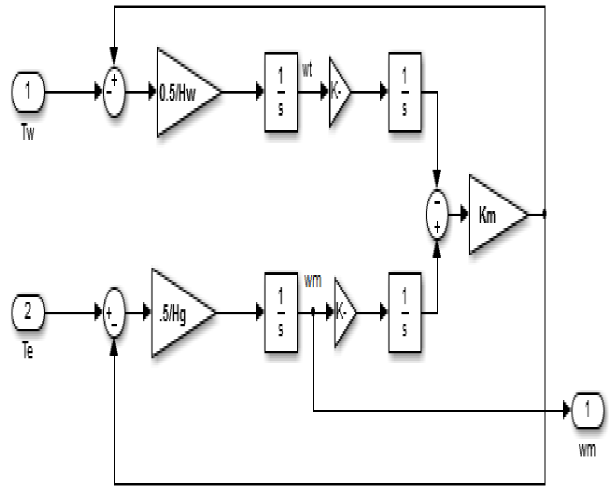

Fig. 6 Mechanical system

DFIG model with stator and rotor parameters are shown in fig. 7. The complete simulation model of DFIG with PI controller is shown in fig. 8.

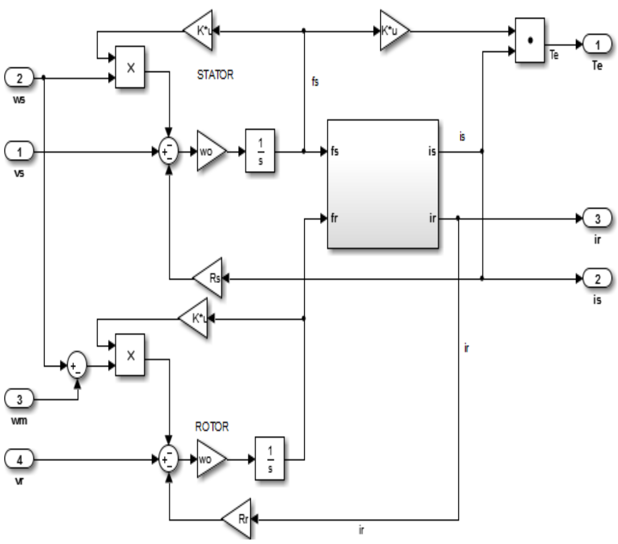

Fig. 7 DFIG Simulink model

Figure 9 shows the results of doubly fed induction generator with PI controller.

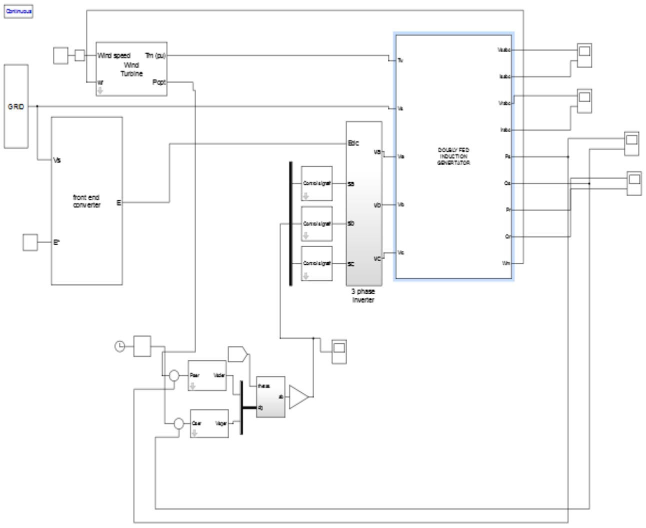

Fig. 8 DFIG with PI controller

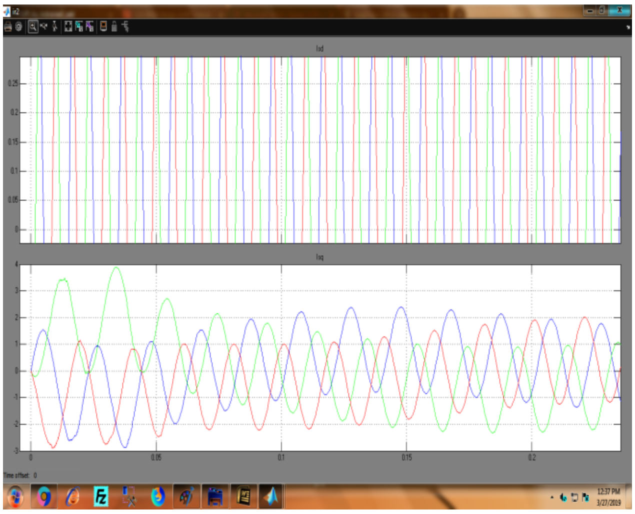

Fig. 9 Stator current for d-q axis

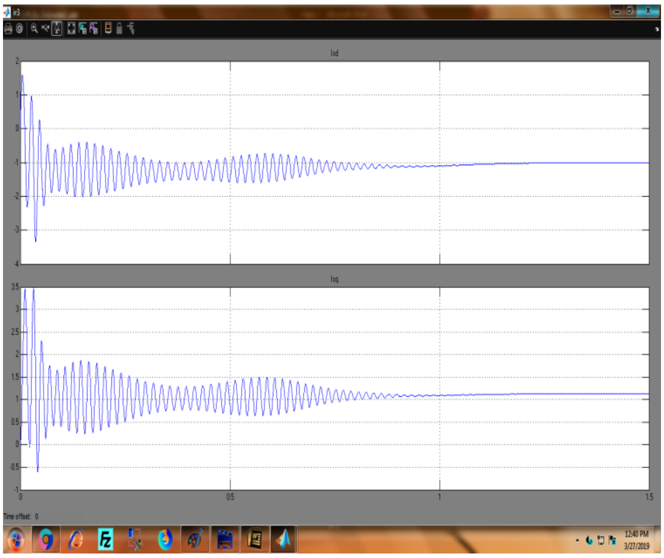

Fig.10 characteristic of active and reactive power after control action

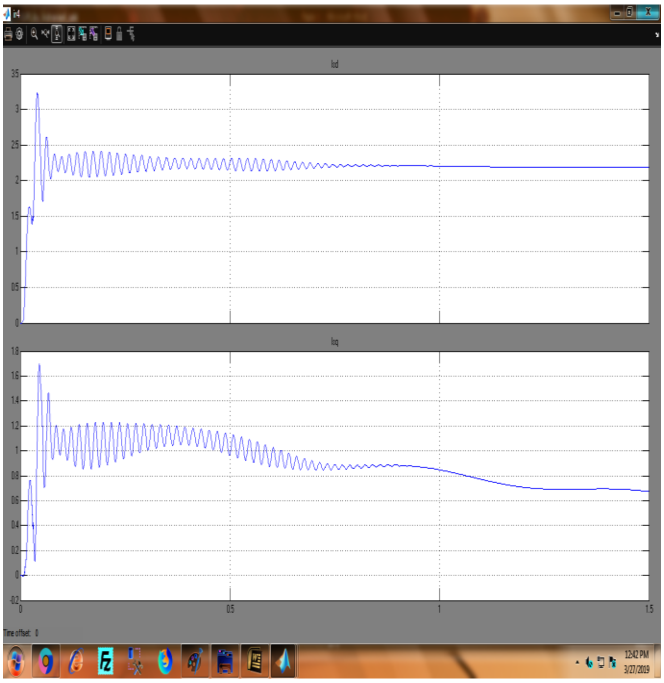

Fig. 11 Rotor currents for d-q axis

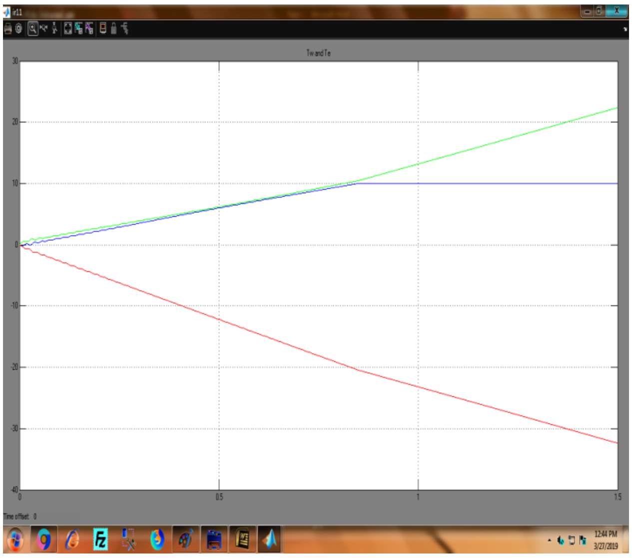

Fig.12. Torque characteristic

V. CONCLUSIONS

In this work we consider the DFIG for the constant operation of the wind plant. As we know that obtaining the stable response of wind power plant is very difficult task. DFIG help us to obtain stable operation but most of the cases it required some controlling action for generating constant output power. Here consider PI controller for the support of the DFIG constant and stable operation. Results of Simulink model of wind generator with PI controller shows the constant operation of the plant. Hence, it's finished that the PI controller with static feedback fed doubly fed induction generator provides stable operation and gives constant output power.

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