RESEARCH PAPER | Engineering | Volume : 3 | Issue : 1 | January 2013 | ISSN - 2249-555X

Control System Based on DSP for wind Turbine

KEYWORDS: DSP, power stabilization, air velocity

Bhupesh Kumar Poosam
Department of Electrical Engg. Jabalpur Engineering College, Jabalpur, MP, India

Mr. Hemant Amhia
Department of Electrical Engg. Jabalpur Engineering College, Jabalpur, MP, India

ABSTRACT *Wind energy is characterized by irregularity, instability & unpredictability. Normally, rotational turbulence of blade and wind parameters viz, speed , density etc. produces unwanted fluctuation. Power output of wind turbine is a function of wind speed. Wind turbine known as source of fluctuated power because it depends on wind speed. This fluctuating power will have its impact on power balance and voltage at the point of common coupling. Small variation in wind speed causes big variation in power output. Consequently, big voltage fluctuation pruduces very large variation in voltage at load side which is out of control. In this paper a method has been developed by which fluctuation in output power of wind turbine can be reduced. A DSP Controller is using for this purpose. The developed method has been tested using a Sim Power System tools of MATLAB and simulated for operation.*

1 INTRODUCTION

Renewable energy resources are known as a means of promising power provider because these are having low cost , advance technology and eco friendly. Renewable energy sources are wind, solar, biomass. Amongst them, wind energy are strongly considered alternative power. The range of advance turbine technology is now reached upto Multi megawatt. Multi megawatt generation capability of wind turbine now comes with better control which is increasing the contribution of renewable energy in power grid. Wind energy sources are characterized by irregularity , unpredictability. Wind power is the function of wind speed and wind speed's behavior is random.

Furthermore, normally, blade rotational turbulence and tower shadow also produces fluctuation on mechanical torque. These all reason make the wind turbine as a source of fluctuating torque which responsible of unwanted power fluctuation . wind power generation system always connected with weak grid. It is poorly interconnected. It is either very far or isolated from main generation unit. In a weak or isolated grid, the response of system voltage or frequency is very sensitive for power generation or power consumption. Fluctuated power also causes the unnecessary start stop of secondary power generator. The wind power inertia compensate certain amount of fluctuation . Though if wind turbine feeds power to load or small grid than this fluctuated power can create a severe problem for system stability. Energy storage device can reduce the power fluctuation as well as power flickering.

A lot of wind generation technology are available in market. Amongst them , DFIG is an attractive option because it can work under variable speed operation , real and reactive power control and with low rating convertor. The main improvement of a recent configuration with a storage system in the DC link is providing an extra spinning reserve facility for the wind system which can be used for sink or source of active power . theoretically , storage system has the capability by which enough real power can compensate so that instantaneous fluctuation can be made smooth.

In this paper , that key elements has been discussed and identified who is responsible for power fluctuation . Also system has been simulated and results are discussed here.

2 Theory

In normal operation condition random properties of wind , tower shadow and blade rotational turbulence produces unwanted fluctuation on mechanical torque . this real power is a function of mechanical torque . in a weak system positive feedback occurs between the power fluctuation and the voltage fluctuation with respect to the same input torque and so the power fluctuation may also increase the fluctuation comes in this torque increases the problem. When appropriate compensator is unavailable in a stand alone system of a load or weak grid , the power variation or fluctuation is proportional to the rate of change on wind speed . The total output of wind generator can be expressed as:

P = Pbase + dal P …….(1)

The total power of wind turbine is a combination of base power and fluctuated power . Equation 1 is showing Total Power where Pbase is a fluctuation free power and dal p is fluctuated power. Fluctuated power can be explained as:

$$\Delta P = \Delta T_m - h\frac{d}{dt}\Delta s \qquad (2)$$

Where $h = \omega \dfrac{J\left(\dfrac{\omega}{p}\right)^2}{S_n}$ = inertial constant; ΔP =Fluctuating power; ΔT_m =Fluctuating torque; Δs =Fluctuating slip; J =Moment of inertia; ω =Angular velocity (rad/sec); p =Number of pole pairs; S_n = Rated capacity (VA);

According to the equation 2 fluctuating torque and fluctuating slip is main component to produce unwanted power fluctuation . fluctuated power has its own magnitude and frequency which depends on the rate of change of wind speed.

3 Modeling of system

Our system consists of a DFIG with DC-AC and AC-DC convertor battery storage , load and grid. Generator uses wound rotor induction machine whwere rotor terminal are fed via a back to back PWM voltage source convertor. Control system is capable to control the real power and active power independently. Rotor side convertor controls the generator speed and reactive power of stator while stator side convertor controls the fluctuating power as well as it supplies the reactive power to the system

Volume : 3 | Issue : 1 | January 2013 | ISSN - 2249-555X

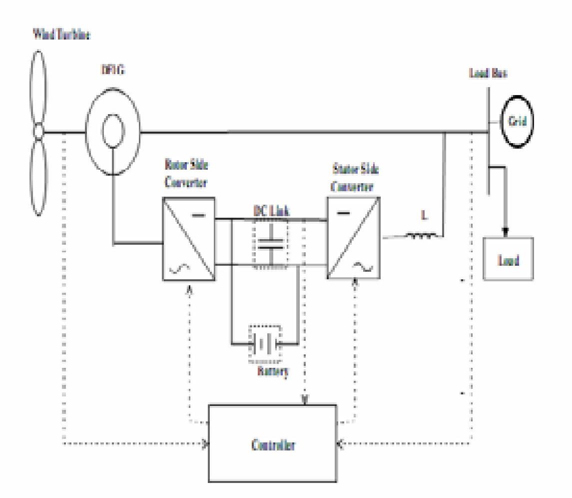

Figure 1. Wind turbine with storage System

Figure 1 shows the typical arrangement of a DFIG equipped with a wind turbine and battery storage system connected to the DC link of the back to back PWM convertor. A DSP controller has designed for this system . Stator side convertor controls the exchange of instantaneous power between stator and storage system.

Storage controllers receive signal from wind energy and grid system. The storage system provides instantaneous active power compensation through the stator side convertor to the turbine output power as well as the DC link voltage stabilization.

4 Wind Turbine Model

Wind turbine is a nonlinear system whose different output depends on optimal values of different parameters. The total power of wind turbine is:

$$P_{wind} = 0.5\rho A_r v^3 \qquad (3)$$

where ρ is the air density [kg/2m], Ar is the area swept by the rotor and V is the wind speed. The wind power output is given by the power curve, depending on the wind speed, which is expressed as

$$P_{wind} = \begin{cases} P_{rated} & \text{for } v_r < v \le v_0 \\ P(v) & \text{for } v_i < v \le v_r \\ 0 & \text{for } v_i > v > v_0 \end{cases}$$

where Vi ,Vr and Vo are the cut-in, rated and cutoff wind speed, respectively. The function, P(v) , describes the wind power between cut-in wind speed and rated wind speed. The mechanical power of wind turbine can be determined by,

$$P_{mech} = P_{wind} C_p(\lambda, \beta) \qquad (4)$$

Cp is the performance coefficient. It is the function of Tip speed Ratio and Pitch Angle. Tip speed ratio is a ratio of speed at the Tip of the blade and speed of the wind. It described as

$$\lambda = \frac{\omega R}{v} \qquad (5)$$

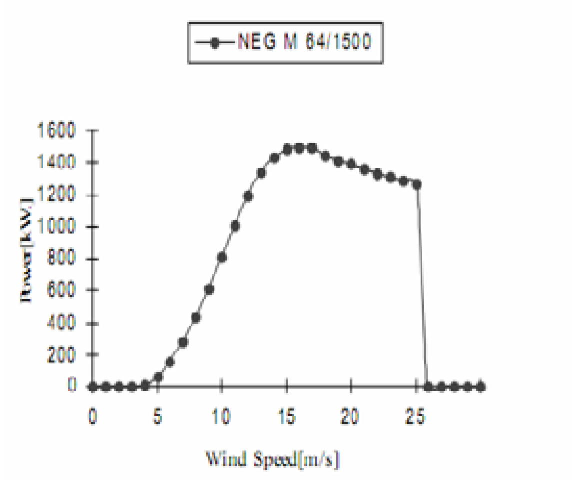

Figure 2. shows a typical power curve of commercially available wind turbine

Figure 3 depicts the performance coefficient of different wind speeds . According to the figure , initially , as the wind speed increases Cp also increases . Further Cp decreases with increasing of wind speed . This characteristic makes the wind turbine output self regulating by operating itself in lower efficiency during high wind speed. It shows the achievement of high efficiency also during low wind speed.

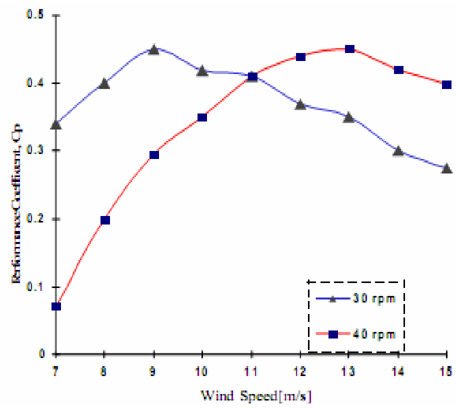

Fig 3 . Performance curve for two different wind speed

Performance coefficient varies with wind speed. Figure 4 showing the power characteristic curve of wind turbine during different wind speed.

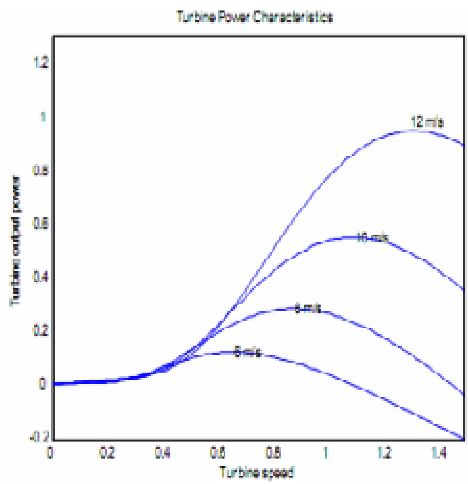

Figure 4. Turbine power characteristic

5 Storage System

The motive of the stirage system is to smoothen the wind

Volume : 3 | Issue : 1 | January 2013 | ISSN - 2249-555X

power variation. The charging and discharging power of storage system can calculate as per the availability of wind power.

$$P_{dch} = \begin{cases} P_d - P_w & \text{for } P_w \leq P_d \\ 0 & \text{for } P_w > P_d \end{cases}$$

$$P_{ch} = \begin{cases} P_w - P_d & \text{for } P_w > P_d \\ 0 & \text{for } P_w \leq P_d \end{cases}$$

Where Pch, Pdch , Pd , and Pw are the charging, discharging, desired and actual wind power, Respectively. The energy storage system can be characterized by its charging efficiency ηch and discharging efficiency ηdch as follows

$$E_{ch} = \eta_{ch}(P_{ch}).P_{ch}$$

$$E_{dch} = \frac{P_{dch}}{\eta_{dch}(P_{dch})}$$

Where Ech is th stored energy and Edch is the discharged energy. The storage system ratin should be less than convertor's rating.

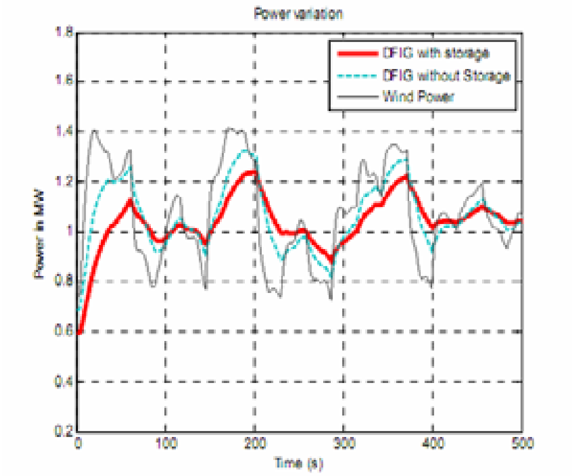

Figure 5. Power variation curve

6 Conclusion

In this paper the discussed method has been developed in MATLAB. The proposed arrangement is able to reduce the power fluctuation.

REFERENCE 1. W.R. Lachs, and H. Tabatabaci-Yazdi, "Energy Storage in Power Systems", IEEE Int. Conference on Power Electronics and Drive Systems, PEDs'99, July 1999, | 2. Rajib Datta and V.T. Ranganathan, "Variable-Speed Wind Power Generation Using Doubly Fed Wound Rotor Induction Machine - A Comparison With Alternative Schemes", IEEE Trans. Energy Conversion, vol.17, No.3, pp. 414-421, Sep. 2002. | 3. Texas Instruments TMS 320 F/C 24x DSP Controller-peripheral library and specific Devices (Reference Guide) |