Scientific Journal Impact Factor (SJIF): 1.711

e-ISSN : 2349-9745
p-ISSN : 2393-8161

International Journal of Modern Trends in Engineering and Research
www.ijmter.com

DYNAMIC PERFORMANCE IMPROVEMENT OF DFIG UNDER UNBALANCED CONDITION USING PID CONTROLLER

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Abstract-This paper proposes the optimal operation and reliable control of the Doubly Fed Induction Generator (DFIG) under unbalanced condition of wind powergeneration system. The active and reactive power is controlled between the rotor and the grid by the converter control. The control strategy is analyzed by using the Simulink model. The aim of the control is to limit the active and reactive power with integration power control loop of indirect control method using a PID controller: proportional-integral-derivative. The rotor current is controlled in this way under fault condition. Finally the simulation result is presented and discussed for the proposed control technique using MATLAB software.

Keywords: Doubly Fed Induction Generator ; power generation system; active and reactive power; PID controller; network unbalance

I. INTRODUCTION

An improved control and operation of a Doubly-Fed Induction Generator (DFIG) System under unbalanced network conditions are the major problems in the present scenario. The DFIG is generally usedin the production of the electric energy and more specifically in wind turbines. For the DFIG continuous operation, we have to improve the transient behaviour as compared with the indirect control without power loop. The most popular rotor-side solution applied by utilities is the implementation of PID controller. To control the voltage level and power we are going to use the PID controller.
Furthermore, it has been reported that the decoupled control of PID controller is effective in preventing the extremely fast grid unbalance condition. The new method should be based on the reliabilities because of more advantages. However, it is also able to overcome the difficulties compared to the other methods.

Doubly Fed Induction Generator

The mechanical efficiency of the wind turbine is largest at wind speed is around 11 ms-1. This is a deliberate choice by the engineers who designed the turbine [1]. At low wind speeds efficiency is not so important, because there is not so much energy to harvest, at high wind speeds the turbine must waste any excess energy above what the generator was designed for [2].

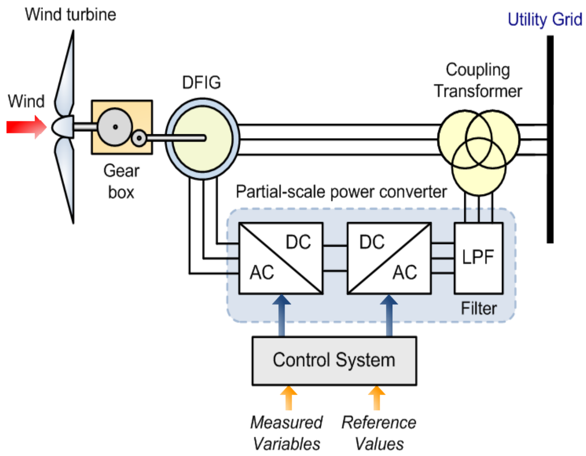


Figure 1 :Block Diagram of a DFIG Wind Turbine

Efficiency therefore matters most in the region of wind speeds where most of the energy is to be found.

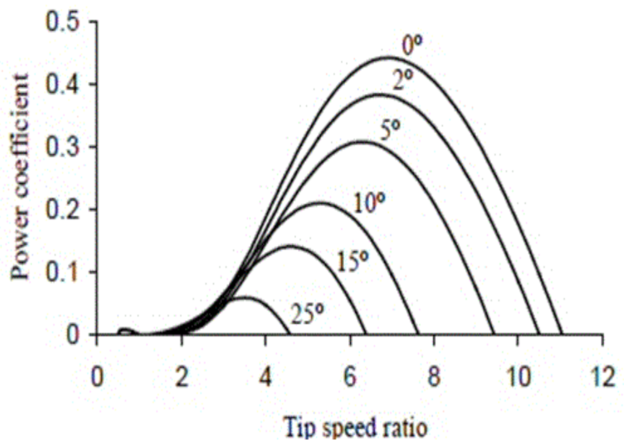


Figure 2 : Power coefficients for the Wind Turbine Model.

Proportional-Integral-Derivative controller

PID controllers are a family of controllers. The reason PID controllers are so popular is that using PID gives the designer a larger number of options and those options mean that there are more possibilities for changing the dynamics of the system in a way that helps the designer[3]. The three terms - the P, I and D terms, are added together to produce a control signal that is applied to the system being controlled.

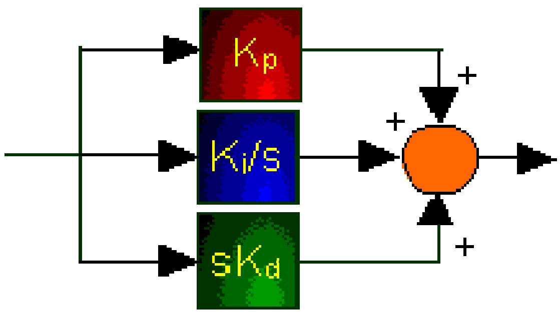


Figure 3:Schematic Diagram of PID Controller

The PID controller transfer function can be obtained by adding the three terms.
PID(s) = $K_p + K_i/s + sK_d$

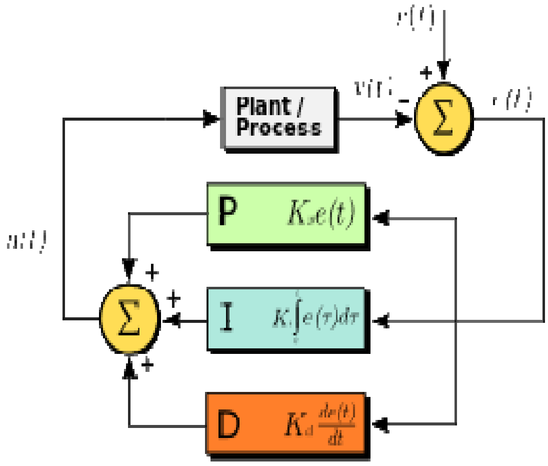


Figure 4 :PID controller In a feedback loop

A PIDcontroller calculates an error value as the difference between a measured process variable and a desired set point. The controller attempts to minimize the error by adjusting manipulated variable. these values can be interpreted in terms of time.P dependonthe present error, I on the accumulation of past errors, and D is a prediction of future errors, based on current rate of change.

Defining u(t) as the controller output, the final form of the PID algorithm is

$$u(t) = MV(t) = k_p e(t) + k_i \int_0^t e(\tau)dt + k_d \frac{d}{dt} e(t)$$

Where

k_p: Proportional gain, a tuning parameter
k_i: Integral gain, a tuning parameter
k_d: Derivative gain, a tuning parameter
T : Time or instantaneous time (the present)
τ : Variable of integration; takes on values from time 0 to the present

II. CONTROL STRATEGY

The plant load is assumed to be the combination of a balanced three-phase diode bridge rectifier followed by the three phase dynamic load, which acts as a harmonic generating load, different single phase loads can be connected on each phase to neutral, with different load active and reactive power demands. Here in the wind generation system the controlling technique is implemented. The feedback control used is PID which gives more advantages then other controllers especially for wind power generation. In the first and the second control, transient oscillation due to the coupling terms between the two axes.

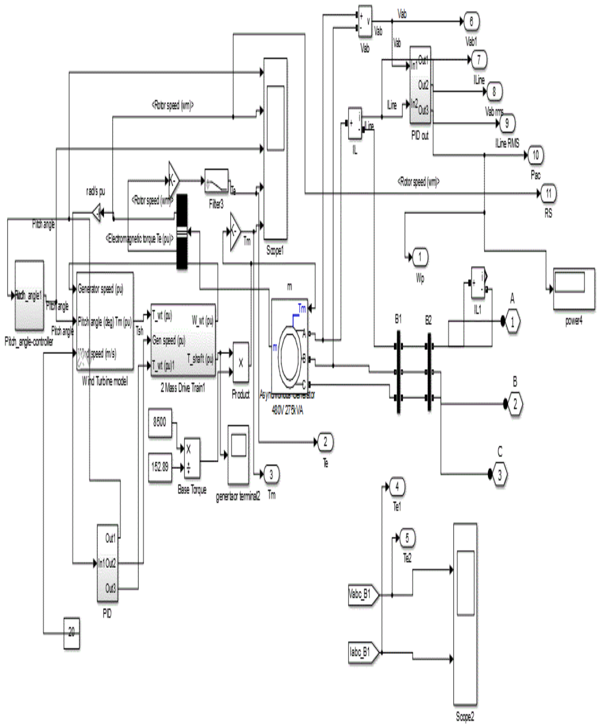


Figure 5 : Block Diagram of PID Controlled DFIG

In the first control, without power loop a static error appears on active and reactive powers, a good tracking and performances in terms of dynamics and responses.

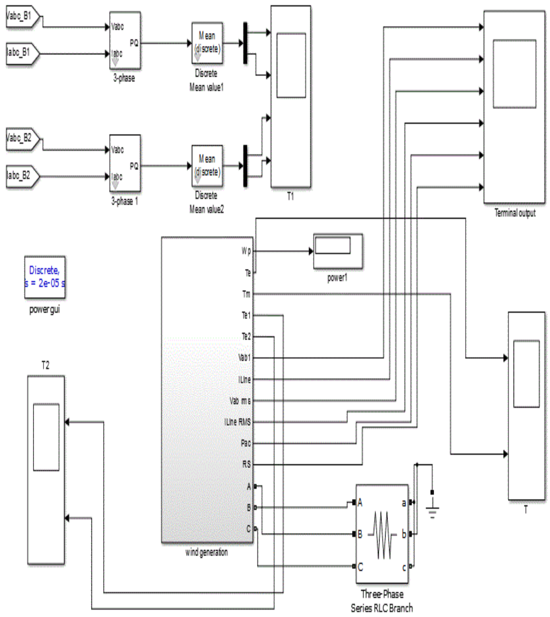


Figure 6:Simulation Diagram of DFIG

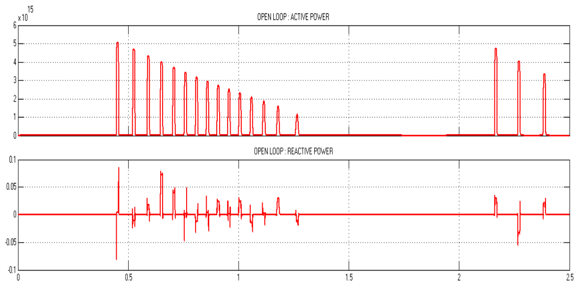
In second control, the control with power loop used satisfies the dynamics system with zeroing the static error in the active and reactive powers. Furthermore, the references of powers are correctly tracked, except that the presence of the oscillations in the occurrence of fault, without any change in the active and reactive powers. Indeed, a high transient current even with highly change during the fault, increasing in the quadrature current as decreasing in the direct current.

International Journal of Modern Trends in Engineering and Research (IJMTER)
Volume 02, Issue 02, [February - 2015] **e-ISSN: 2349-9745, p-ISSN: 2393-8161**

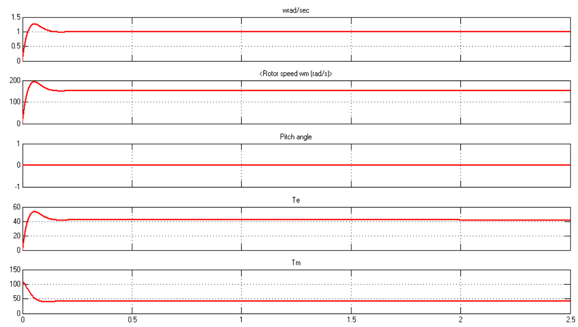
III. RESULT AND DISCUSSIONS

In AC power distribution systems, harmonics occur when the normal electric current waveform is distorted by non-linear loads. When a three phase distribution system is connected with highly non-linear loads, it will affect the total system parameters. The reference values from the grid contain oscillations and the distorted wave forms of voltage active and reactive power of the system.

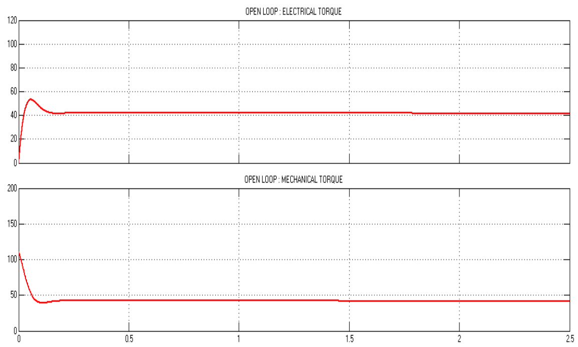
OPEN LOOP



Active and Reactive Powers

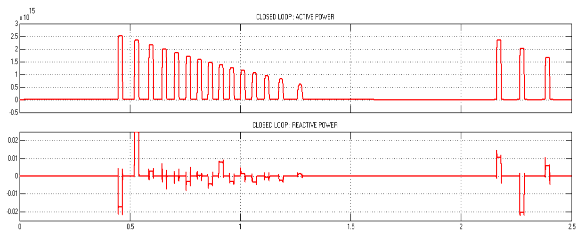


Speed, Pitch Angle, Torque

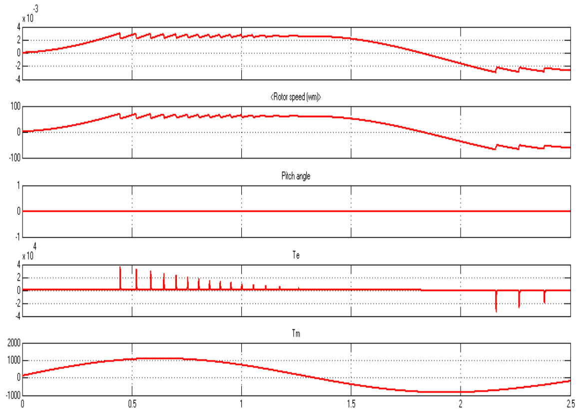


Torque without Controller

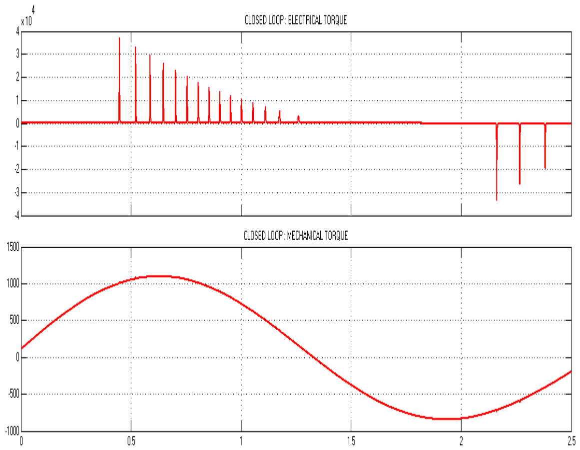
CLOSED LOOP



Active and Reactive Powers



Speed, Pitch Angle, Torque



Torque with Controller

The simulation of the PID controller confirmed the high dynamic performance obtained under fault condition, the capability to ensure an electrical protection for DFIG without losing power tracking, by setting current limitations. It also presents low complexity and cost of implementation.

IV. CONCLUSION

The implementation of PID control over the decoupled method is cost-effective solution, allowing the use of a filter in the same facility. The simulation results show that perfectly balanced source voltage and currents and are free from distortion. The power quality problems like voltage and current unbalance are removed and the oscillation is reduced with control of active and reactive power in grid side.Thus for the reduction of the turbine output power losses a gain value is implemented to reduce the losses in the generator. This improves the overall efficiency of the system.

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BIOGRAPHY

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