VECTOR CONTROL AND DIRECT POWER CONTROL METHODS OF DFIG UNDER DISTORTED GRID VOLTAGE CONDITIONS

Dhayalan A#1 and Mrs. Muthuselvi M#2

#1 PG Scholar, EEE, Velammal Engineering college, chennai, India
#2 Assistant Professor, EEE, Velammal Engineering college, chennai, India

Abstract - Wind energy is one of the most promising renewable energy among all renewable energy resources and so integration of wind to grid will be a better choice. Double Fed Induction Generator is one of the best options among all generators as it can able to extract maximum energy from wind while operating at narrow speed ranges by using back to back power electronic converter. In this project, direct power control and vector control method for grid side converter and rotor side converter of doubly fed induction generator is proposed separately. In direct power control the behavior of Double Fed Induction Generator is analyzed and the active and reactive power references are generated by means of direct power control. Grid Side Converter power references are provided by means of voltage and current sequence extraction. In vector control mode stator flux oriented control is applied. The vector control is applied to Rotor side converter by comparing the reference signal provided by Proportional Integral controller and pulse width modulation is generated and applied to Rotor Side Converter. Similarly the vector control is applied to Grid Side Converter by generating pulse width modulation. Stator flux oriented control is applied to decouple the control of active and reactive power.

Index Terms – Power Quality; Grid Side Converter (GSC); Rotor Side Converter (RSC); Proportional Integral controller (PI); pulse width modulation (PWM); doubly fed induction generator (DFIG).

I. INTRODUCTION

Electrical generation is one of the leading causes of industrial air pollution. Renewable energy resources can be used to produce electricity with fewer environmental impacts. It is possible to generate electricity from renewable energy sources without pollution. Among all the renewable energy resources wind energy has been widely accepted in power industry as a result of its cleanliness cost effectiveness. Wind speed changes naturally causing change in speed of turbine and results in variable output voltage.

Power electronics converters can be used to achieve an adjustable output voltage in terms of both frequency and magnitude. To achieve a variable speed constant frequency system, an induction generator is considered. One solution to expand the speed range and to reduce the slip power losses is to excite both the stator and rotor windings. The power converters in the rotor circuit can regenerate the majority of the slip power. Variable speed operation can be adopted in one of two ways: direct ac to ac frequency converters, such as the cycloconverters or using voltage controlled inverters (ac-de-ac An AC-DC-AC converter is added in the induction generator rotor circuit. The rotor power will be typically about 25% nominal generator powers.

II. METHODOLOGY

A. Mechanism of Wind Power Generation

The wind blows on the slanting blades of the rotor, causing it to spin, converting some of the wind’s kinetic energy into mechanical energy. Sensors in the turbine detect how strongly the wind is blowing and from which course. The rotor automatically turns to...
face the wind, and automatically brakes in dangerously high winds to protect the turbine from damage. A shaft and gearbox connect the rotor to a generator so when the rotor spins, and hence generator rotates. The generator uses an electromagnetic field to convert this mechanical energy into electrical energy.

B. Doubly Fed Induction Generator

The doubly-fed induction generator (DFIG) system is a popular system in which the power electronic interface controls the rotor currents to attain the up-and-down speed necessary for highest energy capture in variable winds. The DFIG offer the advantages of speed control with cheap cost and power losses.

C. Operation at Sub-Synchronous Mode

A doubly fed induction generator (DFIG) based variable speed wind turbine can be capable of operating in both sub-synchronous or super-synchronous mode of operation using power electronic converters.

![Fig. 1. Operation at sub-synchronous mode](image)

During the sub-synchronous mode of operation, the speed of the rotor is less than the machine synchronous speed. As a result the slip becomes positive (s>0), and hence a motoring torque will be produced. To utilize this torque, a negative power according to the positive slip is required in the rotor circuit of the machine to increase the speed. These can be achieved by changing the magnitude of the injected voltage to the rotor circuit and the rotor receives power form the DC link. The DC link gets power through GSC.

D. Super-Synchronous Mode

In super-synchronous mode, the rotor speed is greater than the synchronous speed and hence slip is negative i.e s<0. The rotor voltage/current sequence has to be reversed in order to supply extra generating power to the grid. The extra power from rotor was supplied to grid by back to back converter. The magnitude of the rotor current and voltage is changing according to variations in wind speed. Between the two converters, a dc-link capacitor is placed, as energy storage and the main objective for the grid-side converter is to maintain the dc-link voltage constant. With the rotor-side converter it is likely to control the torque or the speed of the DFIG and also the power factor at the stator terminals.

![Fig. 2. Operation at super-synchronous mode](image)

E. Direct Power Control

The constituent of the stator current has to be prohibited to control the stator active power and has to be controlled to control the stator reactive power. This is achieved in turn by controlling the rotor currents, in conventional field oriented control strategy. The effect of injection of these rotor currents on the air-gap and rotor fluxes can be derived by subtracting and adding the respective leakage fluxes. The reactive power is fed completely from the stator side. Under this condition if is varied from 0 to full load. It can be concluded from the above discussion that

i) The stator active power can be restricted by calculating the angular position of the rotor flux vector.

ii) The stator reactive power can be controlled by controlling the magnitude of the rotor flux vector.
These two ideas are used to find out the instant switching state of the RSC to control the active and reactive power.

DPC is based on the instantaneous active and reactive power control loop and no internal current control loop. The aim of every direct control approach is to reduce the error among reference and actual values. This is done by selecting the appropriate converter output voltage vector to push the state of the system towards the reference values. In this case, the controlled values are instantaneous active and reactive power components of the stator and the grid respectively. No coordinate transformations are required. In this control technique, the control scheme is implemented in both RSC and GSC. Fig.3 shows the block diagram of DPC in DFIG and the instantaneous power of DFIG and grid.

A vector control approach is used with a reference frame oriented for enabling independent control of the active and reactive power flowing between the grid and grid side converter (GSC).

III. SIMULATION RESULTS

A. Vector Control Of DFIG

This section is concentrated on description of vector control techniques, which have been developed for DFIG using back to back PWM converters, are applied in the speed control scheme. Fig. 4 shows the speed control scheme is composed of two vector control schemes designed respectively for the rotor side and grid side PWM voltage source converter. The objective of the vector control scheme for the grid side PWM voltage source converter is to keep the DC link voltage constant.
Under unbalanced grid voltage condition the main grid could be polluted due to unbalanced stator current the wind turbine could be damaged. Therefore it is disconnected from network. The distorted stator current under such condition have been balanced by vector control technique. The entire simulation has been carried out in Matlab/Simulink software.

The balanced stator current has been produced after eliminating the disturbances using LCL filter. Therefore a pure sine wave is obtained.

**B. Direct Power Control of DFIG**

Under unbalanced voltage grid operation conditions, it has been shown that a simple DPC technique accompanied by a correct active and reactive power reference generation stratagem is able to eradicate the electromagnetic torque oscillations and interchanging sinusoidal currents with the grid. by using an oscillating stator active reference, it is possible to make certain sinusoidal stator currents exchange, thus avoiding the need to calculate the positive- and negative-sequence components.

Under unbalanced grid voltage condition the main grid it is disconnected from network. The distorted stator current under such condition have been balanced by vector control technique.
Under unbalanced grid voltage condition the power seems to be lagging due 0.92 to distorted stator current.

The balanced stator current has been produced after eliminating the disturbances using LCL filter and therefore a pure sine wave is obtained.

The power factor in both the systems was found to be nearly unity.

It is inferred that due to the complexity of the structure the equipment cost will be initially high compared to direct power control.
V. CONCLUSION AND FUTURE SCOPE

Under unbalanced voltage grid operation conditions, it has been shown that a simple DPC technique accompanied by a proper active and reactive power reference generation strategy is able to eliminate the electromagnetic torque oscillations, thus avoiding mechanical stresses in the wind turbine and interchanging sinusoidal currents with the grid. In vector control, the stator flux oriented vector control scheme is integrated with the DFIG to recognize the quick and accurate control. On comparison it is inferred that the results of DPC is better compared to vector control except in case of harmonics. We may also implement direct power control and vector control methods of DFIG under distorted grid voltage conditions.

VI. REFERENCES


