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RESEARCH ARTICLE

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POWER QUALITY IMPROVEMENT IN DFIG DRIVEN WIND FARM CONNECTED TO GRID USING STATCOM

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ABSTRACT
In recent years, Renewable energy utilization is increases because of increasing in power demand by consumer. So uses of non-conventional energy generation are growing. These non-conventional energy generation required converter for stable output power. In this wind energy generation is occupy major part. Due to use of converter in wind forms non-liner current & voltage magnitude are generated in power system. Utility are facing some problems such as transient stability, voltage regulation, damping of power oscillation, power flow control, etc. Among shunt FACTS devices STATCOM has been recognized as a good tool and perfect compensator to solve these problems. To validate the results of STATCOM a simulated model is designed when sudden load variation occurs in power system. The results proved the effectiveness of the STATCOM in restoring the system stability.
KEYWORDS: Static synchronous compensator (STATCOM), wind generation, power quality, control strategy, power system.

1. INTRODUCTION

Due to its clean and economical characteristics, the wind energy is the fast growth and the most developed technology over the past decades. According to EWEA reporting, 12% of the worlds electricity is generated from wind power and the wind generation capacities has been changed around 5000 MW in recent years [1-4]. During a large disturbance, such as a grid fault, deregulated electricity industry, the policy of open entrance to transmission system, have created competitive electricity markets which be caused the high wind generation penetration levels in the power system. Also, the growth of power transfer capability of transmission systems has been a major problem during a large disturbance recovery, over the past two decades. Further because of new constraints placed by economical and environmental factors and under high wind generation penetration levels in the power system, the power quality of the wind farms has become a significant issue for both power systems and customers. Under these situations, the modern power systems are facing some major challenges such as voltage regulation, power flow control, transient stability, and damping of power oscillation, etc [5]. Among flexible AC transmission system (FACTS) devices STATCOM can be the best solution to these problems. Initially, at the end of the 1990s, STATCOM used to alleviate line overloads, provide rapid active and reactive power compensations to power systems. Therefore it can be used to reduce voltage drops, flicker, and electrical losses in the network. The main functions of STATCOM are; reducing transient stability, minimise power oscillation damping, voltage support and power flow control [6-7].

In this paper we discuss about the grid connected wind energy system using STATCOM. STATCOM consist of voltage source converter which gate pulses are generated by PI controller technique. This PI controller generates gate pules from comparing reference signal which are getting form transformation theory. This complete model is simulated by using MATLAB/SIMLINK block.

2. WIND GENERATOR

The main element of wind energy is the wind generator. This latter uses the kinetic energy of the wind to rotate the shaft of the rotor in order to convert mechanical energy and then itself be converted into electrical energy. There are various types of wind generator out of them double fed induction generator having more advantages over all of them. Amount of power provided by wind to rotor for converting wind energy to electrical energy depends on density of air , rotor area and velocity of wind [8]. The power contained by wind is given by,

P =0.5*(air mass flow rate)*(wind velocity)^2

= 0.5* (ρ* A *V) * (V)^2

=0.5ρAV^3

Where,

P = power contained in the wind (W)

ρ = air density (kg/m3)

A = rotor area (m^2)

V=wind velocity before rotor interference (m/s)

The power coefficient (Cp) describes the efficiency of a turbine that converts the energy in the wind to rotational power. Therefore power output of the turbine is given by

P_0 = 0.5ρA^{3}Cp------- (2.1)

The tip speed ratio of the wind turbine is defined as

$\lambda=\omega R/V$ --------------- (2.2)

where,

R = radius of the swept area in meters

ω= angular speed in radians per second.

Cp varies with change in λ. CP-λ characteristics ofa turbine is necessary to develop the turbine model. Most wind turbines in the world use three-phase asynchronous (squirrel cage or wound rotor) generator to connect to the grid. One reason for selecting this type of generator is that it is very consistent, and relatively inexpensive. The power from the wind turbine rotor is transferred to the generator through a power train (i.e. through the low speed turbine shaft, the gearbox and the high speed generator shaft). Power curve of a WEG is a graph that indicates the electrical power output at different wind speeds. Power curves are presented along with commercial models of WEGs.

3. DOUBLE FED INDUCTION GENERATOR (DFIG)

The wind DFIG converter consist of AC/DC/AC converter is divided into two components: the rotor-side converter and the grid-side converter Fig 1. Shows the block diagram of wind farm with DFIG. Rotor side converter and grid side converter are Voltage-Sourced Converters that use forced-commutated power electronic devices (IGBTs) to synthesize an AC voltage from a DC voltage source. A capacitor connected on the DC side acts as the DC voltage source. A coupling inductor is used to connect converter to the grid. The three-phase rotor winding is connected to rotor side converter by slip rings and brushes and the three-phase stator winding is directly connected to the grid. The power captured by the wind turbine is converted into electrical power by the induction generator and it is transmitted to the grid by the stator and the rotor windings. The control system generates the pitch angle command and the voltage command signals rotor voltage and grid voltage for rotor side converter and grid side converter respectively in order to control the power of the wind turbine, the DC bus voltage and the reactive power or the voltage at the grid terminals[9].

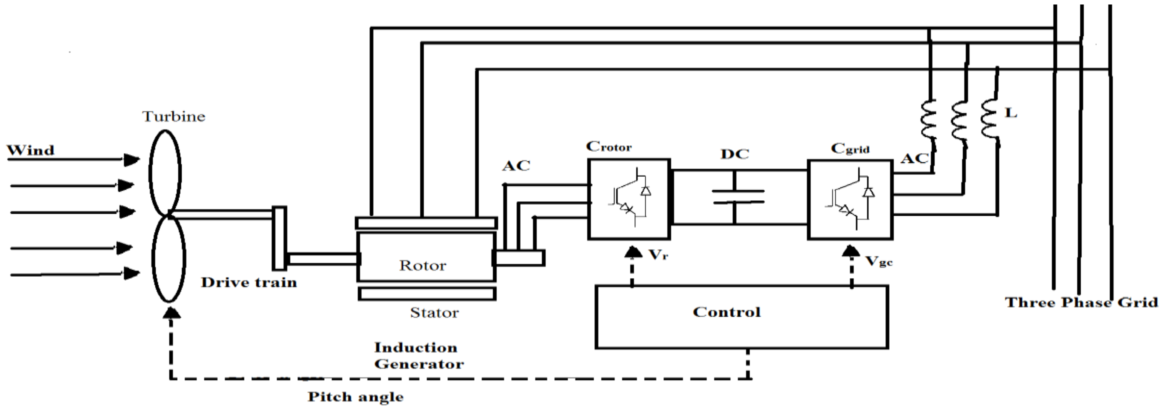

Fig1. Block diagram of Wind turbine with DFIG

4.STATCOM DISCRIPTION

The shunt-connected custom power device, called the STATCOM is often used in transmission system. Static synchronous compensator (STATCOM) is avoltage source inverter based power electronic device.Usually, this device is supported by short-term energy stored in a DC capacitor. When a STATCOM is associated with a particular load, it can inject compensating current so that the total demand meets the specifications for utility connection. Alternatively, it can also clean up the voltage of a utility bus from any unbalance and harmonic distortion. We propose a STATCOM topology that can work in either the voltage or current control mode. In a voltage control mode, the STATCOM is connected at a utility bus to maintain a balanced voltage at that bus, irrespective of unbalance or distortion in either side of the bus. In this mode, the operation and maintenance of the STATCOM is the responsibility of the utility. Alternatively, in the current control mode, the STATCOM compensates for any unbalance or distortion in the load. Ideally, it should draw a balanced current from the system, irrespective of any unbalance or harmonics in either the source or load. It is also assumed that the STATCOM is placed at a utility bus or on customer premises. Therefore, the source is not assumed to be inflexible. The following Fig 2.shows the single line diagram of STATCOM. Generally, the STATCOM configuration consists of a typical 12 pulse inverter arrangement, a dc energy storage device; a coupling transformer connected in shunt with ac system, and associated control circuits, as shown in Fig 2.

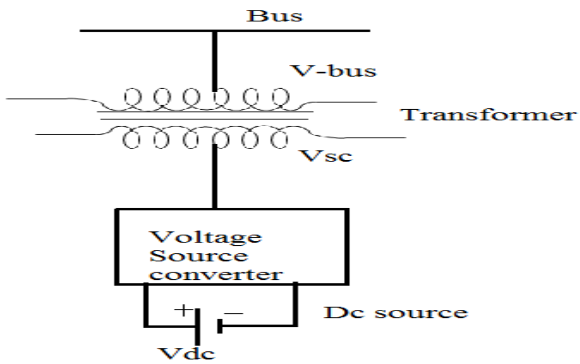

Fig.2Single line diagram of STATCOM

The voltage source inverter converts an input dc voltage into a three phase output voltage at fundamental frequency. These voltages are in phase and joined with the ac system through the reactance of the coupling transformer [10].

4.1PI CONTROLLER FOR STATCOM

A PI lead controller is a proportional gain in parallel with an integrator; both in series with a lead controller. The proportional gain provides fast response. The integrator drives the system to a 0 steady-state error. PI controller is one of the most widely sought after controller in industry as it is the simplest to design following Fig 3. Shows the block diagram of PI controller for STATCOM.

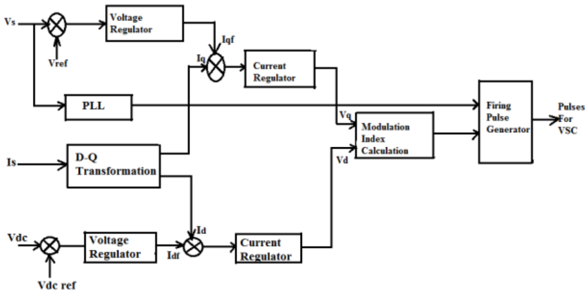

Fig. 3 Block diagram of PI controller for STATCOM

The control technique is depending up on the principal of a-b-c to d-q transformation. The output of PLL is used to measure the angle between components of three phase voltages. The external regulation loop consist of the ac voltage regulator provides the reference current (   ) for the current regulator that is always in quadrature with the terminal voltage to control the reactive power. PI control is employed for voltage control a supplementary regulator loop is added with the help of DC capacitor voltage [11].

5. SIMULATED MODEL & RESULT

The simulation model consists of wind turbine with doubly-fed induction generator (WTDFIG) and STATCOM are shown in the Fig 4. Called Wind Turbine with Doubly-Fed Induction Generator System by using STATCOM.

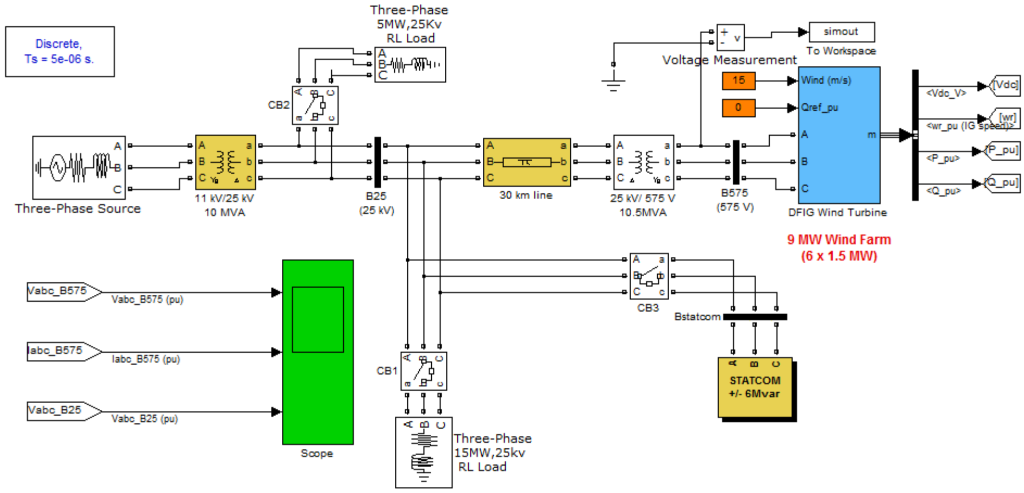

Fig.4 simulation block diagram of wind DFIG connected to grid with STATCOM

The wind input provided to the system is of 15m/s according to that input output is generated by using DFIG is fed to 575V bus then it step up to 575/25KV by using step up transformer for connecting to grid network of 25KV grid. The power is transmitted to a distance of 30Km and it connected to a load of 5MW and 15MW the switching period for load is 0.5sec and 1sec respectively. Firstly the readings are taken without STATCOM at per unit reference to see the grid disturbance by sudden load changes. Fig 5.a show the fig

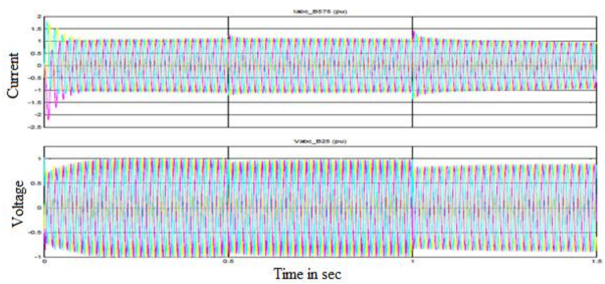

Fig 5.a Voltage and current near load without STATCOM

From Fig 5.a we know that the load is added at 0.5 sec and 1 sec the voltage at bus 25KV is droop down and at the same instant current is increases at bus 575V. In order to remove the grid disturbance the STATCOM of 6 Mvar is connected to the grid network at point of common coupling the transition time set for STATCOM is 0.4 sec. The 5MW load is switch on at 0.5 sec and another load of 15MW is added to the network at 1 sec the load disturbs the grid network the effect is easily removed by using STATCOM at p.u reference the following Fig 5.b shown the system with STATCOM. The voltage near STATCOM is shown in Fig 5.c

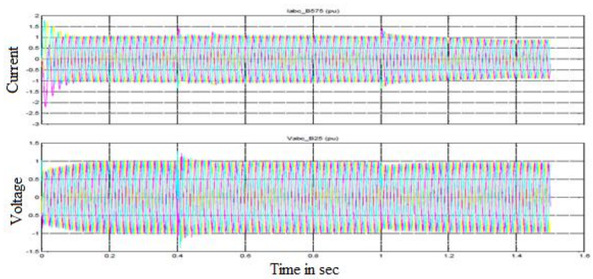

Fig 5.b Voltage and current near load with STATCOM

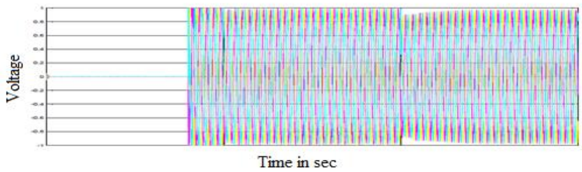

Fig 5.c Voltage of STATCOM

From Fig5.b and 5.c it observe that STATCOM can effectively remove the disturbances in order to compare the result at 25KV grid network a comparison programme is written and the input from Simulink model was fed to the programme and both result going to compare at 575V bus and the graph of with and without STATCOM was drawn in Fig 5.d

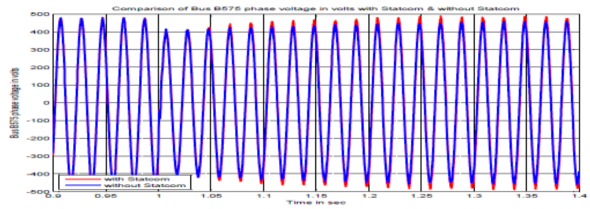

Fig 5d. comparison with and without STATCOM

From above Fig. 5d it is observe that the variation created by load was easily removed by STATCOM with the help of reactive power support. For detail observation the readings are taken out with and without STATCOM.

6.CONCLUSION

The simulation model of wind farms connected to grid with STATCOM and without STATCOM are describe here from the above simulation result we know that STATCOM is the best compensating tool for injecting or absorbing reactive power in to the system in order to balance the system, remove harmonics distortion and all other effect cause by temporary phenomenon of voltage sag, swell and interruption. The load in the system is added at 0.5sec and 1sec and STATCOM was easily remove the disturbances cause by the load a comparative programme shows the voltage output at 575V bus with and without STATCOM.

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