Control of Power flow in DFIG generators for variable speed wind turbine using STATCOM

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ABSTRACT

This paper presents to generate reference voltage for a static compensator (STATCOM) operating in voltage control mode. The proposed the individual wind turbine using STATCOM of dynamic wind farm electric network, of a Power Flow Control of DFIG Generators for Wind Turbine Variable speed using STATCOM is connected to the grid. The control capability of the wind farm that is a critical issue in paining and working of the wind system. The dc link capacitor to exchange the power with the three phase feeders, the power-quality issues by providing load balancing and voltage regulation on the load can be satisfied with the proposed method..

Keyword: - *DFIG, Wind, STATCOM, Power Converter and Matlab Simulink*..

1.INTRODUCTION

In recent years, the Electricity production from the hydro, solar, wind, geothermal, tidal, has come under increasing attention [1-2]. A lot of new novel topologies in power converters are being used now days and has improved power flow techniques. To produce the power from wind turbines more effectively and dependably, to wind power plants, a lot of improvements of wind turbine technology and electrical component [4-5]. The wind farm can be located on the land or in the ocean [7].

The creation of power form wind generators are getting to be distinctly increasing. In 2010, more than 10% of Europe's power from wind generators [8]. To connect the onshore and offshore wind farms to electric power system, high voltage HVDC transmission line system. The WEC efficiency, reduce mechanical stress and improve grid power quality [9-11]. One type of wind power system is a fixed and variable speed wind turbines directly connected DFIG [12]. The active and reactive power requirement of DFIG and improve the power quality. The control stream is resolute capability and location of displacement of power produced by the distributed and the grid voltage, the same previous and then afterward. The more powerful control stream, it is basic to fulfill a control over the control stream between the medium voltages.

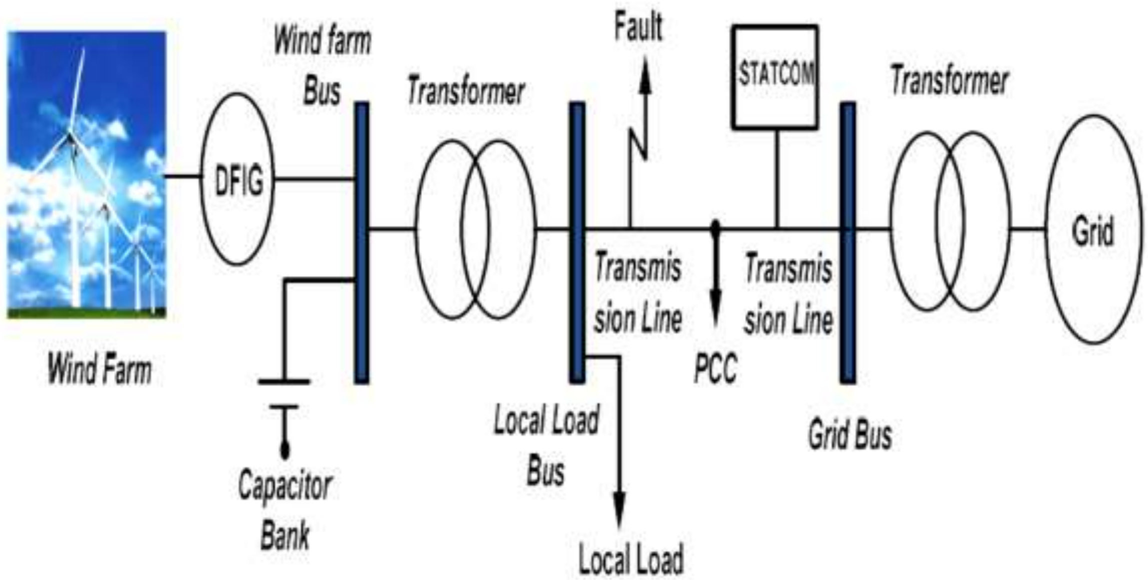

Fig-1 Proposed Single line block diagram

2. POWER FLOW CONTROL

Power flow is a steady state condition whose objective is to verify the voltages, streams, real and receptive control streams in a scheme under a given load conditions. The distribution unit utilizes a voltage source inverter, it's give in real and receptive power, including size and stage point, as expressed in

$$P = \frac{V_s V_{cf}}{X} \sin \delta \tag{1}$$

Where

Vs = equivalent maine volatge
X = equivalent line reactance
Vcf = equivalent recieving end load volatge
δ = Phase angle

$$V_A \cos \beta = V_{source} \tag{2}$$

$$\frac{V_A \sin \beta}{X_q} = I_{A_{source}} \tag{3}$$

3. DOUBLY FED INDUCTION GENERATOR(DFIG)

Nowadays especially for variable speed wind turbines view of DFIG. The voltage and magnetic flux on the stator in DFIG model using d-q reference frame can be written as [13-14],

$$\begin{cases} V_{ds} = R_s.i_{ds} + \frac{d}{dt}\psi_{ds} - w_s\phi_{qs} \\ V_{qs} = R_s.i_{qs} + \frac{d}{dt}\psi_{qs} - w_s\phi_{ds} \\ V_{dr} = R_r.i_{dr} + \frac{d}{dt}\psi_{dr} - w_r\phi_{qr} \\ V_{qr} = R_r.i_{qs} + \frac{d}{dt}\psi_{qr} - w_r\phi_{dr} \end{cases} \tag{4}$$

Where $w_r = w_s - P.\Omega$

$$\begin{cases} \psi_{ds} = L_s.i_{ds} + M.i_{dr} \\ \phi_{qs} = L_s.i_{qs} + M.i_{qr} \\ \psi_{dr} = L_r.i_{dr} + M.i_{ds} \\ \phi_{qr} = L_r.i_{qr} + M.i_{qs} \end{cases} \tag{5}$$

Where $L_r = M_r.I_r$; $L_s = M_s.I_s$

L_s , L_r : Cyclic inductance of stator & rotor
I_s , I_r : Inductance of stator & rotor phase
M_s , M_r : Mutual inductance of stator & rotor
M: maximum mutual inductance
The active and reactive power of rotor & stator of the DFIG

$$\begin{cases} P_s = V_{ds}.i_{ds} + V_{qs}.i_{qs} \\ Q_s = V_{qs}.i_{ds} + V_{ds}.i_{qs} \end{cases} \tag{6}$$

3.1 Wind Turbine

The model of the wind consists of gusts and rapid wind speed changes. The wind velocity (V_w) can be written as

$$V_w = V_{wb} + V_{wg} + V_{wr} \tag{7}$$

Where,
V_w = Total wind speed
V_{wb} = Base wind speed
V_{wg} = Gust wind component
V_{wr} = Ramp wind component
The base wind speed is a constant and is given as
V_{wb} = constant
The wind turbine is modeled from the following system equations [9, 10],

$$Tw = \frac{1}{2}.\rho.S.n^3 \tag{8}$$

$$T_w = \frac{1}{2}.\rho.S.C_p(\lambda, b).n^3 \tag{9}$$

$$\lambda = \frac{\Omega_t.R}{n} \tag{10}$$

$$C_p(\lambda, b) = a_1\left(\frac{a_2}{\lambda_1} - a_3 b - a_4\right)e^{-a_5/\lambda} + a_6\lambda \tag{11}$$

$$\frac{1}{\lambda_1} = \frac{1}{\lambda_1 + 0.8b} - \frac{0.035}{b^3 + 1} \tag{12}$$

Where ρ is the air density, n is the rotor disk radius, C_p is power coefficient, pitch speed ratio (λ) and pitch angle (b).

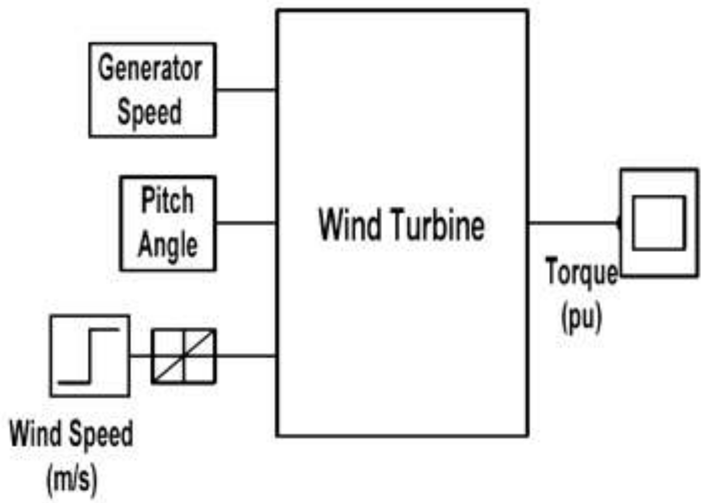

Fig-2 Modelling of Wind turbine

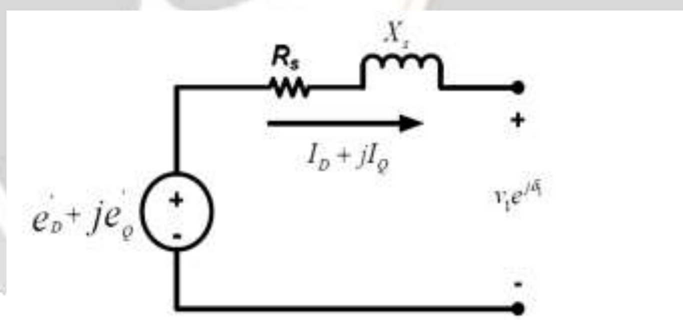

Fig-3 Equivalent circuit of stator flux oriented reference frame

In Fig-3, stator flux oriented algebraic equation of equivalent circuit is written as :

$$e_D = R_s.I_D - X_s.I_Q + v_1\cos(\delta_1) \tag{13}$$

$$e_Q = R_s.I_D - X_s.I_D + v_1\sin(\delta_1) \tag{14}$$

Here stator resistance (R_s) of induction generator. The wind turbine output power written as

$$P_{meas} = \mathrm{Re}\left\{v_1 e^{j\delta_1}(I_D + jI_Q)^*\right\} \tag{15}$$

$$P_{meas} = v_1\cos(\delta_1)I_D + v_1\sin(\delta_1)I_Q \tag{16}$$

3.2 STATCOM

The AC voltage is directly proportional to the DC voltage (V_{dc}) shown in Fig.4. The advantage is response is much faster to changing system condition. The active and reactive power flows from the leading and the source voltage magnitude.

$$I_r = \frac{V - F}{X'} \tag{17}$$

Where generated Voltage (F), bus voltage (V), reactive current (I_r) and inductor (X').

$$P = \frac{V_{bus} V_{vsc}}{X_L} \sin\delta \tag{18}$$

$$Q = \frac{V_{bus} V_{vsc}}{X_L} \cos\delta - V_{bus}{}^2 \tag{19}$$

Where δ is the angle difference between system bus voltage and STATCOM output voltage [6].

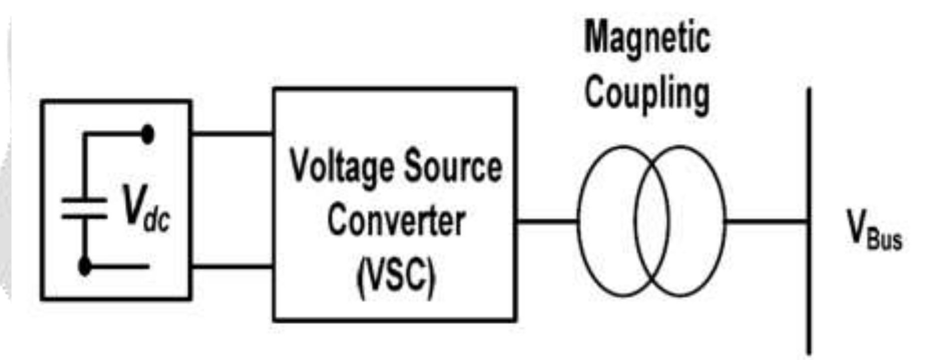

Fig-4 Model of STATCOM

3.3 GRID CONNECTED MODE

The unusual state voltage side the dissemination 12 kHz used as the switching frequency for both side.

$$P_{sc} = P_{grid} = \frac{V^2_{AB source}}{X_L} \tag{20}$$

$$P_{sc} = \frac{V^2_{AB}}{wL_{grid}} = \frac{V^2_{AB}}{2\Pi f L_{grid}} \tag{21}$$

4. ANALYSIS OF SIMULATION RESULTS

The study of a wind power based on DFIG using STATCOM as shown in Fig-1. The simulation parameters are shown in Table-1.

Table-1 : System Parameters for simulation

Parameters	Value
Base Voltage (V_{base})	460 V
Transmission line length	20 km
Resistance	0.1153 Ω
Inductance	1.05×10^{-3} H
Load Parameters	20kV, 5MW
Rated Voltage	380/440 V
Rated Frequency	50 Hz

The power flow control at, Fig-5 and Fig-6 observed the 3- phase voltage and current of the grid, the slip of wind turbine bus shown in Fig-7. The rotor speed of the wind turbine and voltage of wind turbine bus (p.u) is shown in Fig-8(a) and Fig-8(b) observed the wind turbine voltage after 2 sec to 3.5 sec small disturbance of wind, means faults created. The active and reactive power at load using STATCOM is shown in Fig-9.

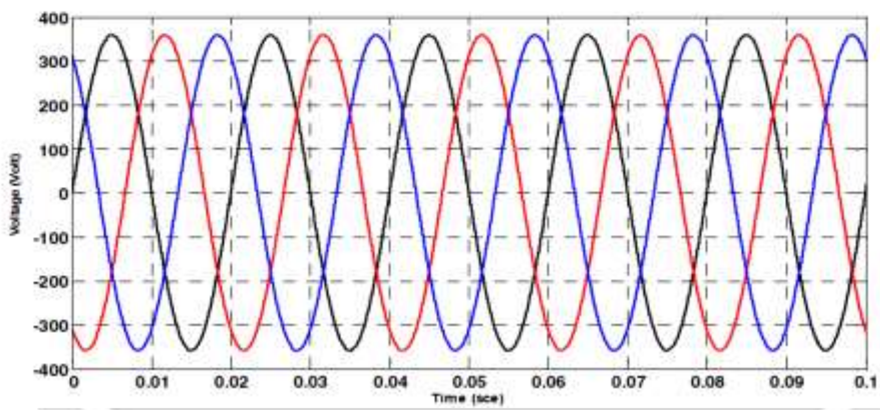

Fig-5 Three phase Voltage

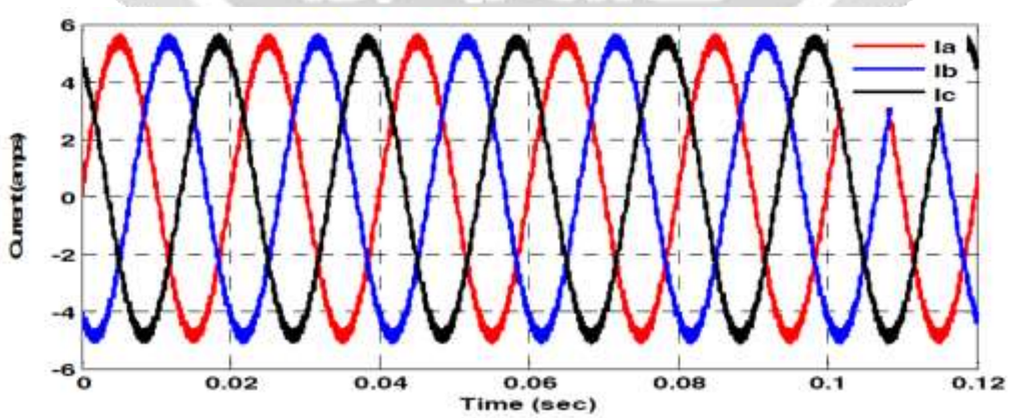

Fig-6 Three phase current

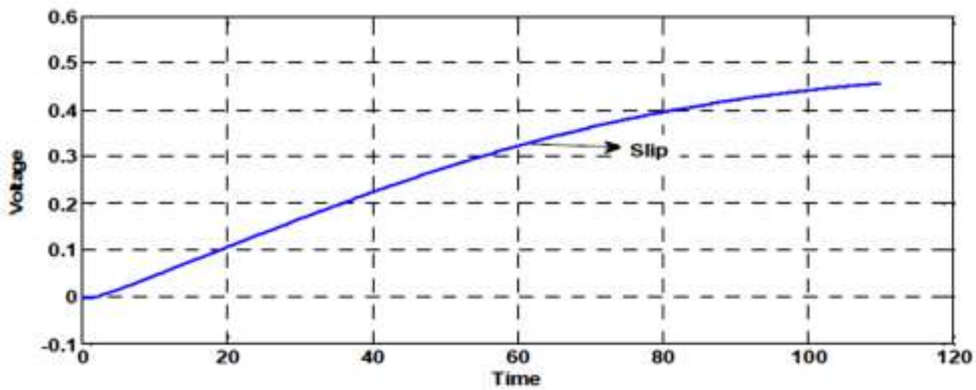

Fig-7 Slip of wind turbine bus (p.u)

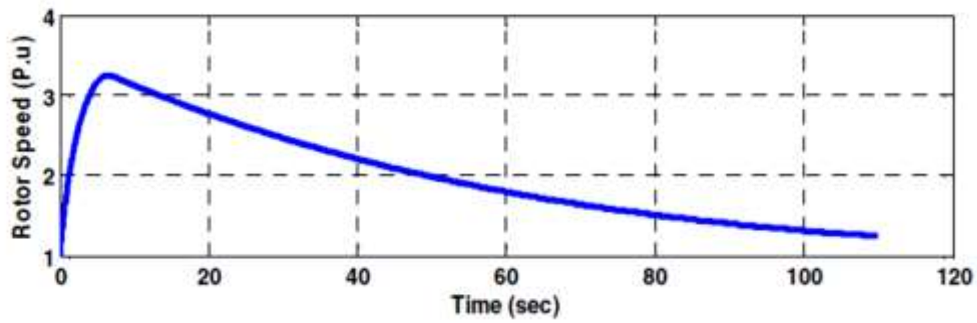

Fig-8 Rotor Speed of wind turbine (p.u)

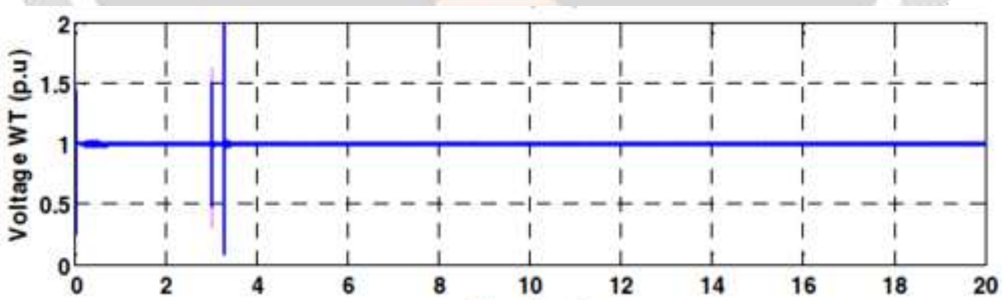

Fig-9 Voltage of wind turbine bus (p.u)

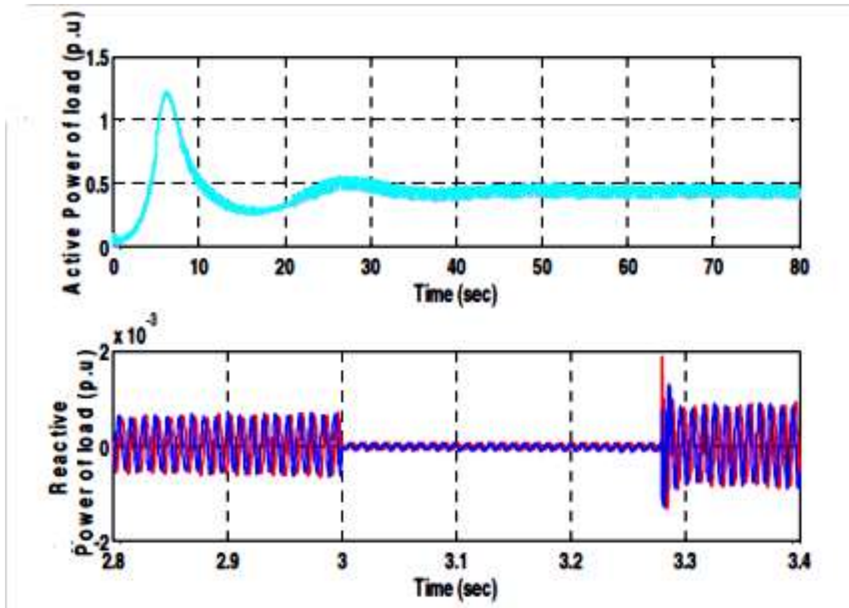

Fig-9 active and reactive powers at load using STATCOM

5. CONCLUSIONS

In this paper wind turbines variable speed based on DFIG using STATCOM was proposed. The equivalent circuit and the mathematical for the new wind power included system. Further, the operating mechanism on the active and the reactive power compensation for the wind farm are investigated. The STATCOM will improve the stability of the system and improve the dynamic performance of the system. The control capability of the wind farm that is a critical issue in paining and working of the wind system.

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