Symmetrical Voltage Dips Analysis In A Wind Turbine Based on Doubly Fed Induction Generator

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Abstract- *Symmetrical voltages dip analysis study in this paper performance of doubly fed induction generator DFIG based on wind turbine. A DFIG based wind generator affected by grid fault as its stator windings are interface to grid. The DFIG are presented along with the mathematical wind turbine modeling and maximum power point tracking of wind turbine operation variable speed wind turbine (VSWT). Mainly propose to control strategy for a DFIG connected to grid, using Grid code requirement. The grid side faults of DFIG based wind generator to overcome the symmetrical voltage dips effect using crowbar. The proposed crowbar inserts a resistance in the fault current pass. The insertion resistance not only limit the fault current but also protection of rotor side control and grid side control also improve stability of the power system by consuming excessive energy if DFIG during fault. MATLAB/Simulink software carried out the simulation.*

Keywords- Doubly fed induction generator (DFIG), Grid code, crowbar, variable speed wind turbine (VSWT), symmetrical fault, wind generator.

I. INTRODUCTION

The technology advancement and industrialization electrical power demand all around the world. Rapid exhaustion and limited stock coal, gas, etc. this fossil fuel is produce energy with harmful pollution in our environment. Among the increase renew able energy source like wind, solar, hydro, bio-mass, tidal etc. the wind energy fastest growing and most prominent option to generate electric power, due to cleaner, cheaperrenewable nature. Among the most used and available technology for doubly fed induction generator (DFIG) based wind turbine. It greater benefits for variable speed wind turbine (VSWT) popular option for harnessing energy from the wind. Due to variable speed operation, the total energy production is 20% to 30% higher capacity utilization factor is improved reduced the energy cost KWh [1]. the stator winding are directly connected to grid while rotor winding are interfaced to grid via the rotor side converter (GSC) and the Grid side converter (GSC) both are connected to back- to -back through DC-Link capacitor. When a speed of the generator is below the synchronous speed and upper synchronous speed totally controlled by both Converter RSC and GSC. This paper analysis symmetrical grid fault to damage the DFIG, due to flow in high value current and low voltage. The effects to overcome used crowbar and also to protection is provide by RSC and GSC converter. The crowbar techniques are to overcome the problem and improved and improved system stability and performance result in MATLAB/Simulink.

II. VARIABLE SPEED WIND TURBINE MODELING

In this paper has been the horizontal axis wind turbine. The main components of a wind turbine system in the turbine rotor, gearbox, generator (DFIG), transformer and control power electronic device are included.

Aerodynamic model evaluates turbine torque (Tt) as a function of wind speed (Vv) and turbine angular (mechanical) speed (Wr). Turbine blade evaluates the pitch angle dynamics as a function (β).Electrical system and mechanical system and **evaluates** the generator and turbine angular speed (Wm, Wr) as a function of turbine torque and generator torque Tem. Control system evaluates the generator torque, pitch angle and reactive power wind speed and grid voltage as a function.

The wind energy produced by the wind turbine generator system (WTGS) is suggested to fluctuation of the wind speed that initially hit the turbine bleeds.

Total wind power conversion into electrical power (electricity) will necessitate the use of controllable power converters all most made of IGBTs.

The perturbation mainly due to stability problem of input variables (wind speed, pitch angle, tip speed ratio) forced to design consider.

The power contained in the form of kinetic energy in the wind crossing at a speed Vw, surface area A expressed by[3]and [4]Pm= $\frac{1}{2}\rho A C_p V_w^2$

The commonly used mathematical relation for the mechanical power harnessed (exploit) from the wind, can be expressions: Pw = $\frac{1}{2}\rho A C_p V_w^3$

Where, Cp is the coefficient of performance also called power coefficient. A is the swept area of the turbine blades (m^2) ρ is the air density (kg/m^3), Vw is the wind speed (m/s)
The coefficient of power (Cp) depends on two basic parameters: tip speed ratio (λ)and blade pitch angle (β B) (dig). Equation can be rewritten as,[3] and [4],

$$Pw = \frac{1}{2}\pi\rho C_p(\lambda, \beta) R^2 V_w^3$$

$$A = \pi R^2$$

The tip speed ratio (λ) is defined as the ratio of the angular speed of the wind turbine to the wind speed at tip of the blades can be following equation $\lambda = \frac{\omega r R}{Vw}$

Where ωr is the angular mechanical speed of turbine rotor (rad/s), Vw is the wind speed (m/s).
The angular velocity related to rotational speed
The rotor shaft driving torque given by equation

$$Tm = \frac{1}{2}\rho A C_t V_w^2$$

Where Ct = torque coefficient given by Ct = $\frac{Cp}{\lambda}$ Based on VSWT (Cp) coefficient is calculated by equation λI = 1/((1/λ+0.02 β)-(0.03/β³+1))
Lambda equation
Cp(λ, β)= 0.73[151/(λi)-0.58 β- 0.02 β²2.14-13.2]$e^{18.4/\lambda i}$

For a particular turbine type, the coefficients from C1 to C6 are C1=0.51, C2=116, C3= 0.4,
C4= 5, C5=21and C6=0.0068.theCp –lambda characteristic for the different values of blade pitch angle(β) is as shown in fig1 and 2.

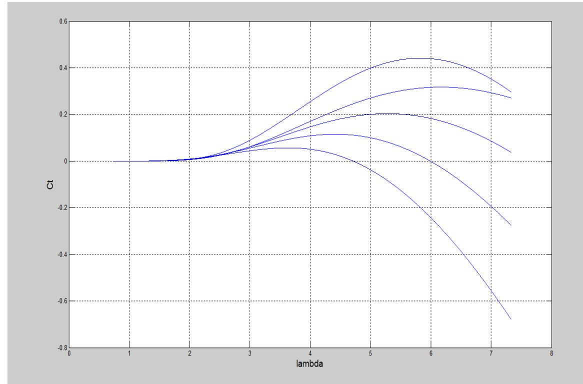

Figure 1.: Turbine's Output Power versus Wind Speed for Varying Pitch Angles

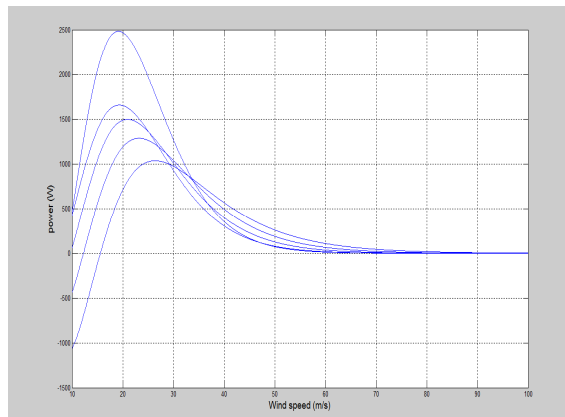

Figure: 2.: Power Coefficient of the Turbine versus Tip Ratio for Varying Pitch Angles

TABLE I. WIND TURBINE DATA

Characteristic	Value
Turbine type	Three blade horizontal axis
Gear box ratio	100
Radio	42m
Air density	1.225 kg/m^3

TABLE II.
DFIG PARAMETERS

Generator Type	DFIG
Rated power	2 MW
Rated stator voltage	690 V
Rated stator current, I_s	1760 A
Rated rotor voltage, v_r	2070V
Stator /rotor turn ratio u	1/3
Inertia J	127
Rated rotational speed	1500
Rated Slip	1/3
Number of Pole Pairs, p	2
Rated Mechanical Torque T_m	12732 Nm
Stator Winding Resistance, R_s	2.6 mΩ
Rotor Winding Resistance, R_r	1.446 mΩ
Stator Leakage Inductance, L_{ls}	0.087 mH
Rotor Leakage Inductance, L_{lr}	0.087 mH
Magnetizing Inductance, L_m	2.5mH

III. THE MODELING OF DFIG

The doubly fed induction generator a single mass system is considered the modeling of wind turbine. The DFIG with Back-to-back through a DC-link capacitor. The park's transformation is in DFIG model. The synchronously rotating d-q reference frame is used where the d-axis aligned with the statorflux in vector position. The stator flux is produced a rotating reference frame same speed. The DFIG parameters used in this study are list in table II.

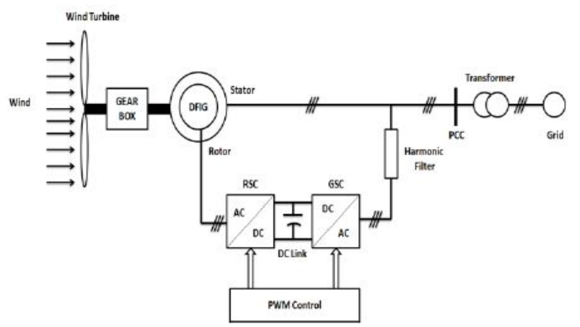

Figure: 1.Basic diagram of DFIG wind turbine.[8]

A.RSC (Rotor side converter)

A vector control is applied to rotor side converter (RSC) to control stator reactive power and the rotor current is proportional to active stator power and torque. The RSC is made by insulated gate bipolar transistor (IGBT) a two- level, six pulses, based full bridge power electronic convertor. The RSCconvertor AC/DC that couples the rotor side to other side the dc link.

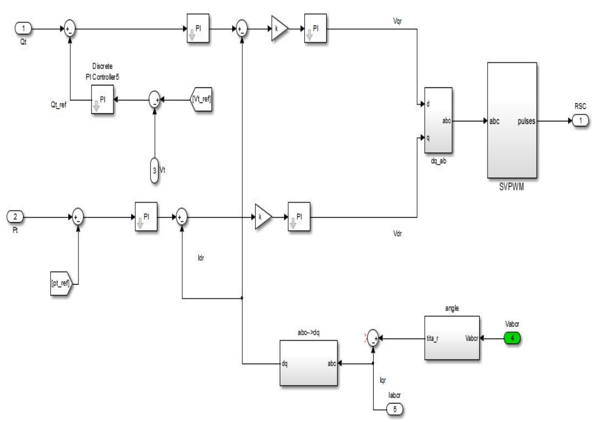

Figure: 2.RSC Controller

It is perform d-q rotor current (id, iq) control by using a regulator (PI) for each component, as shown in Fig. also to be estimated angle (θr) in transformation. The quantity of both voltage and current to control d-q coordinates in d-q reference (ref) value are indicating in Fig.

B.GSC (Grid side converter)

The Grid side convertor is two level six pulses convertor with the dc- side connect with dc-link and ac side connected to grid. It is the stator windings connected to grid through the AC/DC/AC converter as shown in fig. the rotor side converter (RSC) and grid side converter(GSC) are connectimportant to choose an appropriate switching frequency to keep the harmonics minimum level. To obtain the angle (θs), a simple phase locked loop (PLL) can be used to the stator voltage grid synchronization providing perform robustness to the estimated in and rejection in disturbance (small) or harmonic. There for only controlling the Vbus variable to a constant value. This active power flow through the converters is ensured with generate DC voltage both grid and rotor convertors able to work properly. Also be controlled with the reactive power exchange with the grid (Qg). Thus the grid side vector control block diagram shown Fig. it must be current reference (idg*, iqg*) totally decoupled from active and reactive power.

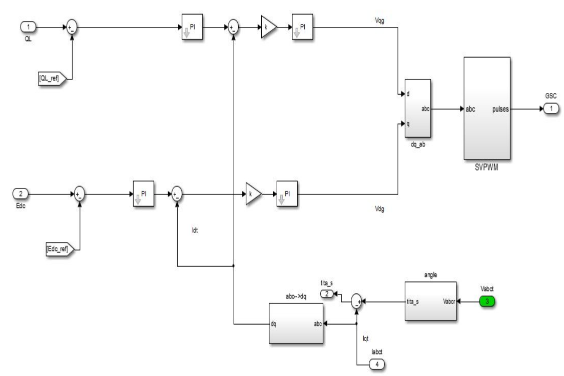

Figure: 3.GSC Controller.

The grid side system three inductive (RL) filter is located between the grid voltage and the convertor output. The DC-link is necessary a power capacitor to smooth out the ripple of the dc voltage. The energy storage capacitor, it tries to maintain a constant voltage in its terminals. This PWM technique allows to maximum achievable output voltage and injected the third harmonics. Also used in PI regulator to given the optimum performance for the system consideration. Otherwise it can change the stability of DFIG is like to compromised. In nonlinear and complex controllers are available in this study.

IV. CROWBAR

The detail modeling of the purposed Crowbar is given below Fig.4.

A.CROWBAR CONFIGURATION

The crowbar is composed of single diode bridge, one switch and one resistance. This resistor put in terminal of the rotor. The 3 phase bridge is composed of diode, a control switch and a resistance. The resistance of the crowbar Rcrowbar must be chosen carefully. There are several alternative crowbar topologies to the shown in the Fig.5.

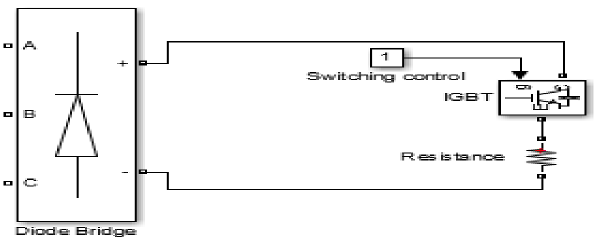

Figure: 5 Crowbar controllers.

B.CROWBAR OPERATION

Once the dip occurs, the rotor side converter is inhabited owing to the quick over current detect in the rotor. When crowbar is activated rotor and grid side converter is must be protected. At a time crowbar connecting the additional resistance path in the rotor damping the high energy flowing in converter or machine. At crowbar is activated in all the current (abnormal energy) should be burned in the protection. After a few milliseconds (100ms), the crowbar can be disconnected and at same time rotor converter is activated.

IV. TEST SYSTEM MODEL

In this work a 2MW, 690KV DFIG based wind generator has been modeled to investigate the fault ride through capability improvement. The DFIG parameters used this model in work are listed in table. The crowbar connected in rotor terminal. The effective performance of crowbar is tested by considering symmetrical fault at grid side.

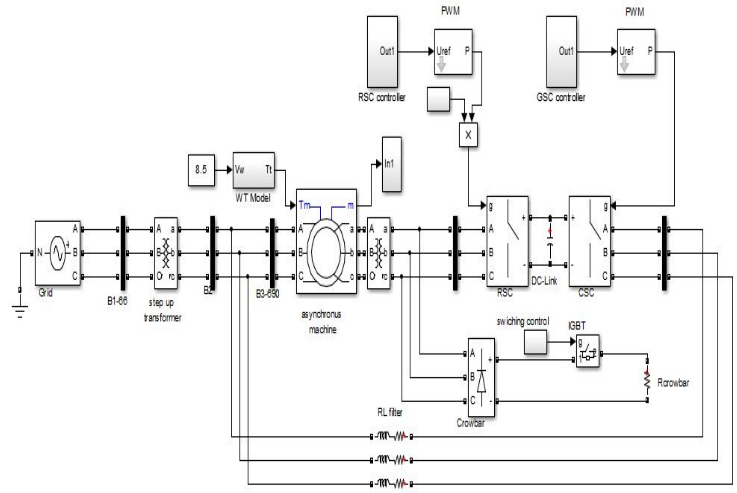

Figure: 6 MATLAB/simulation DFIG with Crowbar test system consideration.

The MATLAB/simulation implementation of DFIG based wind turbine with test system considered in Fig. the DFIG wind generator

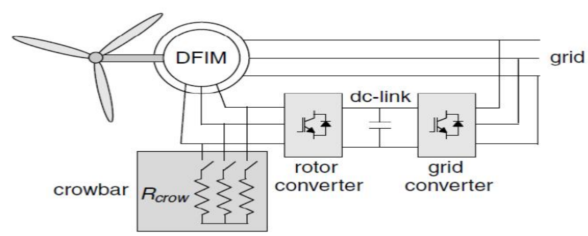

Figure: 4.Basic diagram of Crowbar[6]

is connected to an infinite bus through step-up transformer and a single transmission line. Also in used third harmonic elimination block both are controller. The implementation MATLAB/simulation model DFIG with back-to-back (RSC-GSC) converter. To lessen the harmonic generated by PWM converter, RL-filter is inserted in series with GSC converter. Filter is used eliminate the harmonic produced by the power electronic converters. The Crowbar implementation model and control circuit activation/deactivation generated gate pulse to IGBT.

V. SIMULATION CONSIDERATION

In this paper, the wind speed is considered as constant (8.5m/s), as the duration of the fault is too small for the wind speed to make any considerable effect. The symmetrical fault applied on the test system at grid. Here both controllers are working properly. Just we have programmed 3secthe voltage dip. The rotor voltage Vr is variation, and crowbar activated after 100msec crowbar is deactivated. The Stator flux has gone down one value, and then voltage recovery after the dip is hopingly. And there for also we have stator flux taki8ng at rated value, at crowbar is not activated.

At second 3, we have performed voltage dip and the remaining voltage at the grid only 10% of the normal voltage. Once the voltage dips accurse suddenly the crowbar protection is activated. So, all the energy goes throw the crowbar. The crowbar current variation faster and slower using the crowbar resistance changing. Also same flux reduction faster and slower. The crowbar is activated the all the rotor current goes through crowbar protection. The protection is providing rotor side converter. During this time big torque pick very much related to crowbar current pick, which can't be avoided. The speeds lose control a big quit variation. The high valued rotor current is in order to provide the reactive power through the stator. For the equation Qs=3/2Ws(Lm/Ls) statorflux [idr-(stator flux)/Lm]. The more less the behavior stator current phase shift voltage and current 90 degree, this means providing reactive power. The both controller are working properly.

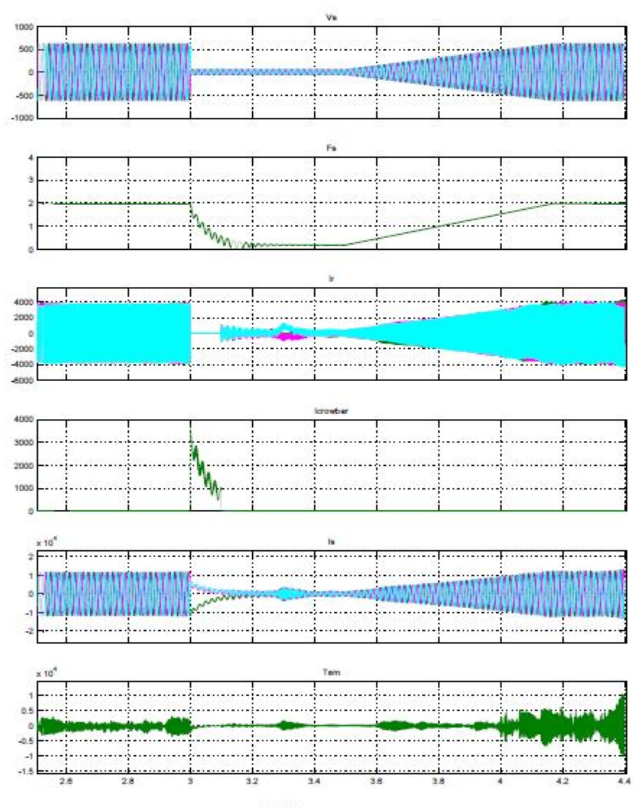

Figure: 6 Simulation results during 3LG fault.

VI. CONCLUSION

The application of the crowbar to enhance the stability of DFIG based variable speed wind generator is proposed in this paper. Simulation results are proved the both converter protection RSC and GSC. The crowbar is every except cost, as seen from graphical and numerical result. Furthermore, an optimal design of the crowbar will be developed considering variable value of the resistance (Rcrowbar).

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APPENDIX B

Parameters Of The DFIG Used For Simulation See Table II.[5]

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