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IMPLEMENTATION OF LOW VOLTAGE RIDE- THROUGH PROTECTION TECHNIQUES FOR DFIG WIND GENERATOR

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***Abstract*—** The Low-Voltage Ride-Through (LVRT) highlights for wind turbines is that they can stay on the web and backing the electric network when fault events happens rather than immediate tripping. With expanding entrance of wind turbines during and after a short-term fault in the grid, the network association codes in many nations it is significant that they ought to stay associated with keep up dependability likewise, for wind turbine it is also important to remain the system stable during and after the fault clearance The DFIG has the upsides of; minimal effort, low weight, and high effectiveness, and one of its fundamental disservices is its affectability to the voltage plunges. Two LVRT techniques for insurance of DFIG during low voltage occasions are looked at. The two methods which are used are Crowbar and series dynamic breaking resistor. These techniques were tried under various sorts of deficiency including balanced and unsymmetrical issues and their exhibitions are thought about. As given above utilizing the Matlab/Simulink quantities of assurance procedures of the DFIG areexamined beneath and reenacted under various conditions.

Keywords*— *DFIG, LVRT, Crowbar, DC Chopper,SDR(series dynamic resistance)

I. Introduction

Due to their operational and economic features in modern variable-speed wind turbines the utilization of doubly-fed induction generator (DFIG) has increased rapidly. The speed variability is ensured by the bi-directional transfer of slip power via the frequency converter and their lower cost compared to the Full Converter Wind generation (Type 4) since the rating of the rotor converter unit is about 25%- 30% of the total power rating of the generator. DFIG machines give steady output voltage and can be directly connected to the grid. Since they are directly connected to the grid, DFIG is very sensitive to grid disturbance like voltage sag, swell, flicker and can create technical issues such as voltage stability, reactive power and fault ride through. In order to reduce the adverse effect on the power system, network operators alternate the grid code requirements[1]. The power transmission between the DFIG and the grid is achieved by two paths; the stator power where the stator is connected directly to the grid and the rotor power where the rotor is connected to the grid via RSC to convert the rotor frequency power to dc power then GSC converts the dc power to the ac system of the grid[1]. The equivalent circuit of the DFIG in the d-q reference frame is shown Figure 1.

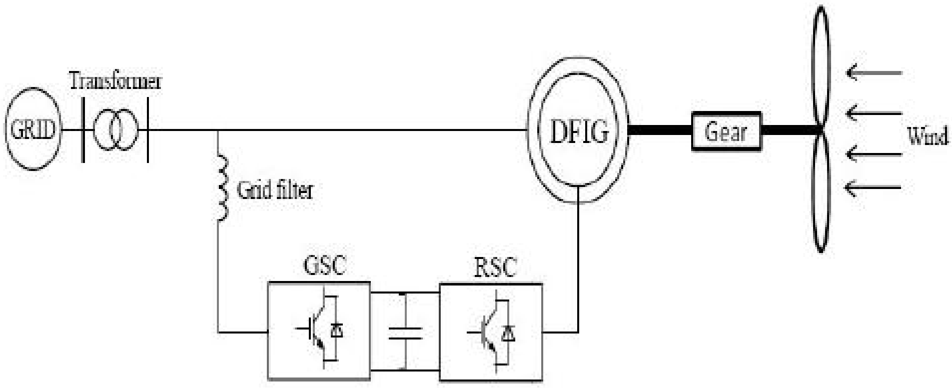

Figure 1 DFIG wind generator System

The increase penetration of wind and solar energy into the power system has resulted in the power system operators revising the grid codes to regulate and control the operation of these renewable resources and minimize their impact on the system. A special focus to the wind turbine fault ride-through capability (LVRT) is of the wind turbine to remain connected to the network during grid faults also; they can contribute to voltage support during and after the fault. The loss of a portion of the grid power generation was due to grid fault when in the past wind turbines were tripped shortly. Under the new grid codes this is not acceptable and the WTG's should remain connected to the grid during a voltage dip for specific period that depend on the voltage dip magnitude[2,3]. The terminal of the DFIG the stator flux cannot follow the rapid change when the voltage dip occurs in the stator voltage and a dc component. The rotor keeps rotating and the machine slip increase, which create an overvoltage and over current in the rotor. Asymmetrical faults cause higher over voltages and over currents in the rotor than symmetrical faults due to the negative sequence components effect.

Special protection techniques are needed to protect the DFIG during these events due to these high transient currents and over voltages during this LVRT event.

II. DOUBLY FED INDUCTIO GENERATOR (DFIG)

Due to the ability to capture more energy of variable speed wind turbine from wind than fixed speed one variable speed wind turbines are more popular. And also have improved power quality and reduces mechanical stress on the wind turbine these are used. One of the most frequently used variable speed wind turbines in generators is the DFIG. The DFIG can run at variable speed but produces a voltage at the frequency of the grid. When comparing to a conventional simple induction generator the electrical power generated by a DFIG is not dependent on the speed. As DFIG is independent of the wind speed it is possible to have a variable speed operation which is possible by adjusting the mechanical speed of the rotor to the wind speed so that the wind turbine operates over a certain wind speed range. Doubly FedvInduction Generator (DFIG) is very important and frequently used generators in wind farms nowadays. It has many advantages which are as follows firstly its low converter rating (The converter rating of the DFIG is 25-30% from thevmachine rating) secondly its relatively high efficiency and many more like lighter in weight, its low cost. Therefore, the DFIG has its important and unique place among many variable speed wind turbine generators.

III. DFIG Theory of operation

As shown in figure 2, DFIG consists of voltage source converters a wound rotor induction generator (WRIG. In this given arrangement the rotor winding is connected via slip rings to the stator and the stator is directly connected to the grid through a transformer. The back-to-back converter consists of two converters, i.e., rotor side converter and grid side converter. A DC link capacitor is located between the two converters, in order to maintain the ripple in the DC link voltage. The main function of the RSC is to control the power factor at the stator terminals and also the torque orvthe speed of the DFIG. On the other hand the function of the grid side converter is to keep the DC link voltage constant also in some cases it may inject reactive power into the grid. The decoupling of the network electrical frequencyvfrom the rotor mechanical frequency and the variable speed operation of the wind turbine generator is obtained when the controllable voltage is injected into the rotor circuit at slip frequency by the power converters.

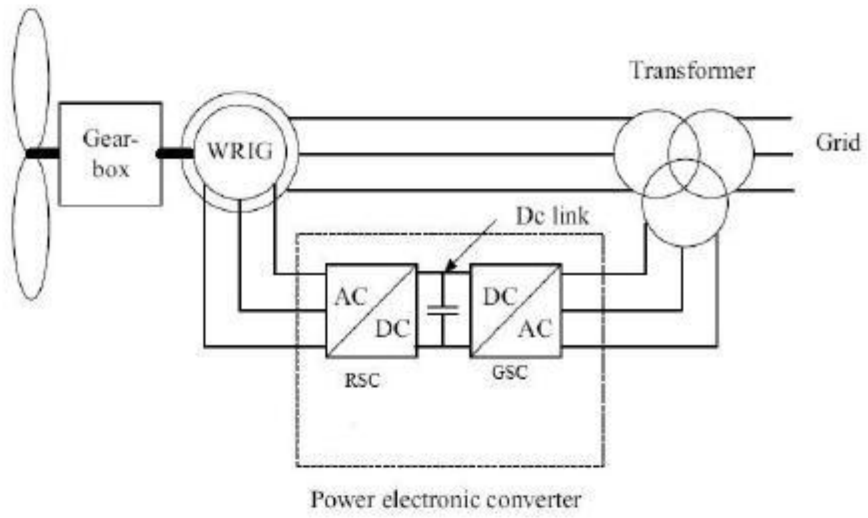

Figure 2 DFIG Scheme

IV. Model of DFIG Wind Generator

The Wind generator models is different from conventional generator models and generally consists of the following elements with different details of modeling level which depend on the study type Wind Speed Model, Aerodynamic Model of the Turbine, Model for the Shaft coupling and gearbox, Generator Model, Models for the power electronic circuits if any (Inverter/Converters), Controller models, and Protection system. Figure 3 shows the overall DFIG wind generation system. In DFIG turbines, he induction generator is a wound-rotor induction machine[6,9]. The stator is directly connected to the grid while the rotor is connected through a back-to-back power converter. The grid side converter is connected to the grid via three chokes to filter the current harmonics. A control system is employed to regulate the rotor frequency (and thus the voltages and currents in the rotor) to extract the maximum possible power from the wind.

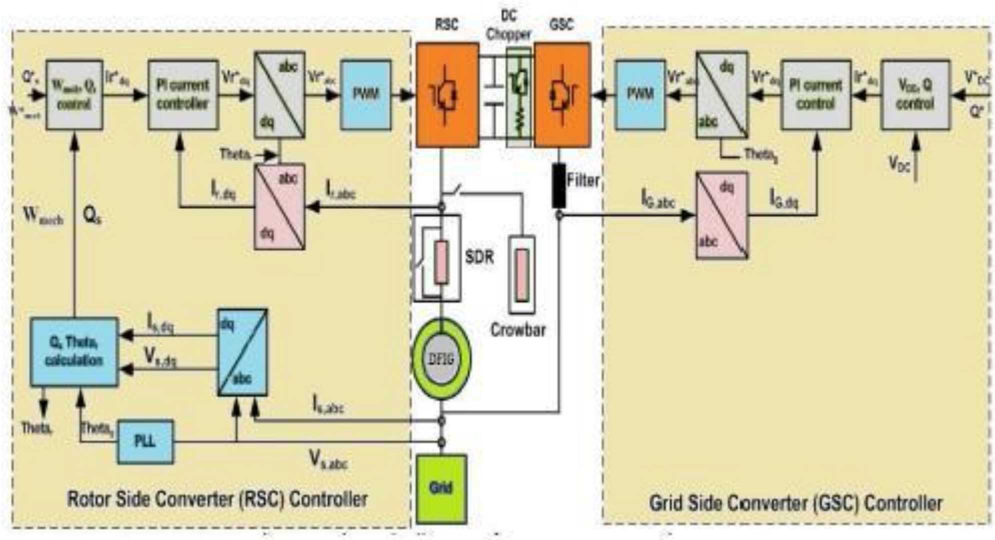

Figure 3 DFIG WTGs Control structure

Modeling of the DFIG includes the modeling of the Machine, the rotor-side converter (RSC), the gridside converter (GSC), the control system and the protection system.

V. LOW VOLTAGE RIDE-THROUGH PROTECTION METHOD

5.1 Introduction

In this chapter we have discussed about the control strategy for the case of three DFIG Wind Generator based on the concepts LVRT Method. LVRT is said to be one of the biggest challenge facing by the wind turbine farms; in particular those which uses DFIGs. The operation and capability of the designed system was analyzed through simulations with MATLAB / SIMULINK.

5.2 LVRT Protection Method

In this work we have used two protection method one is crowbar and another is SDR chopper Method.

5.2.1 Crowbar Method

The considered crowbar protection circuit is composed of three phase diodes bridge and bypass resistors. Until the interruption of DFIG the Passive crowbar control connects the crowbar resistance by passing the RSC .The active crowbar

control scheme is very effective because it connects the crowbar resistance when required and disables it to resume DFIG control without any interruption of DFIG. The crowbar circuit used in this paper consists of three-phase rectifier, power resistor and a series IGBT switch and the turn off ability of the IGBT is necessary for Active crowbar as shown in the figure below. The Crowbar is switch on, when the value of the terminal voltage decrease below the threshold value of comparator and the RSC will be switched off and simultaneously when the terminal voltage exceed the threshold value the Crowbar will be switched off, and the RSC will be switched on.

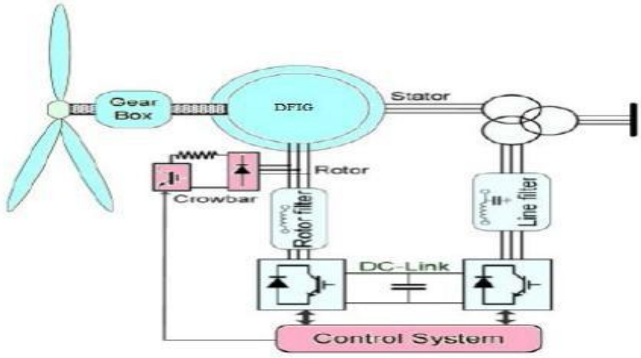

Figure 4 Crowbar Circuit

The crowbar consists of the resistors and switches shown in figure 4. The user can control the switching by adjusting the triggering. By adjusting the value of crowbar resistance, operation of crowbar may differ. By means of providing an additional path to the rotor current and DFIG stay connected to grid the main aim is achieved that is to reduce the rotor voltage. It is the most simplest method and have the advantage of low cost. The main problem is its high short circuit current at the time of RSC thereby drawing more reactive power from the network. There are different methods which can improve the stability and continuity that are passive crowbar, active crowbar and stator crowbar.

VI. SIMULATION RESULT AND DISCUSSION

This section shows the protection technique used in DFIG wind generator in Figure 5 the circuit model without any LVRT protection on the DFIG wind generator.

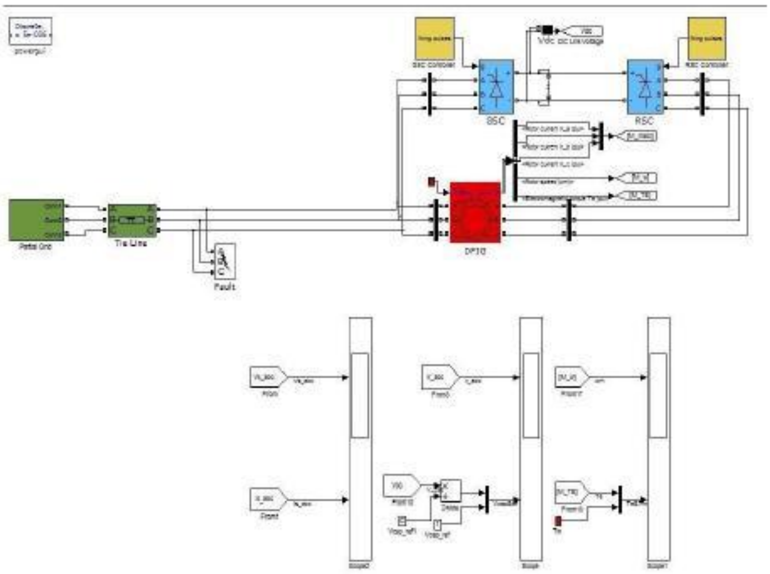

Figure 5 Without any LVRT Protection system Circuit

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This section shows the protection technique used in DFIG wind generator and the Figure 6shows the circuit model of Crowbar Circuit on the DFIG wind generator. This method helps to recover fault condition.

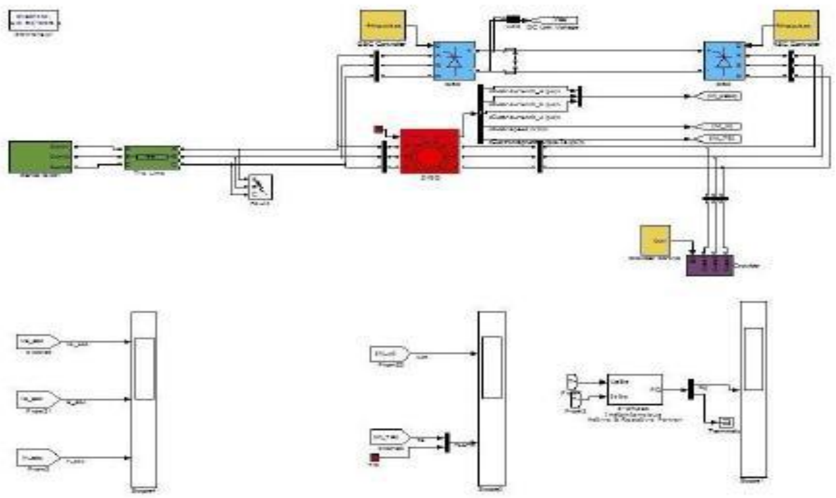
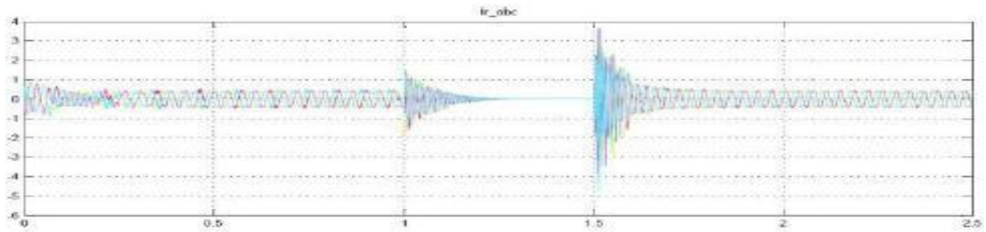


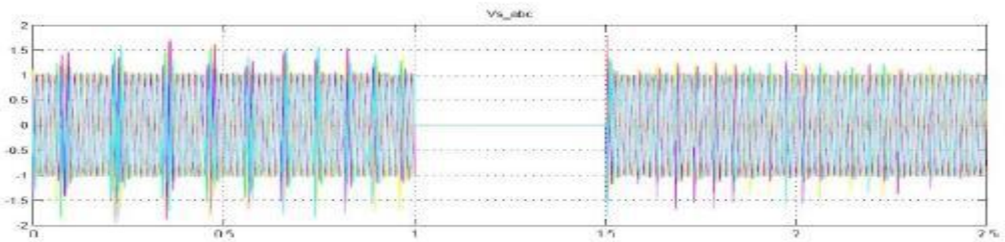
Figure 6 Crowbar Circuit

Protection technique using Crowbar

The Crowbar protection scheme and it reduce the need for reactive power from the grid. The disadvantage of the technique is the small increase in the torque fluctuations during the fault. SDR method can be the best alternative protection scheme for the Crowbar protection circuit. Crowbars are commonly used to protect the power converters during voltage dips. The generator will work as single fed induction generator (SFIG) when crowbar is activated during the faults and the RSC will be switched off, and the machine is out of control as the active and reactive power are not be controlled and this is the disadvantage of the Crowbar protection. (a) Stator voltage (b) Stator Current (c) Rotor Current



(a) Stator voltage



(b) Stator Current

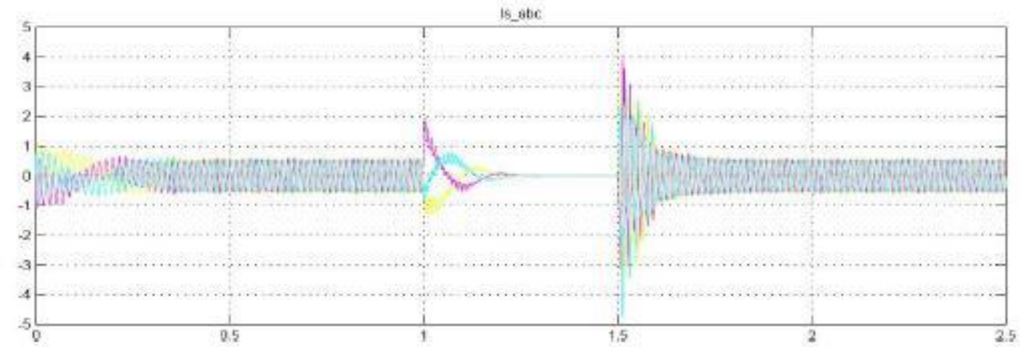


Figure 7 Stator voltage (a), Stator current (b) & Rotorcurrent (c) in crowbar protection

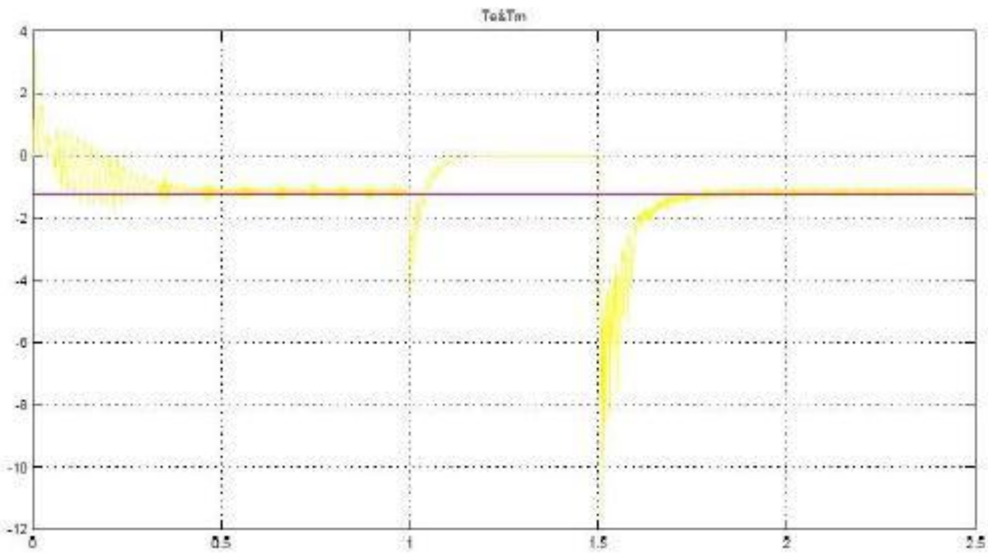


Figure 8 Torque with crow barProtection Method

VII. Conclusion

In this work, Low Voltage Ride Through is an important feature for wind turbine systems to full fill the grid code requirements .Different methods have been studied in this thesis. Crowbar draws more reactive power but are cheap conventional methods. To full fill grid code requirements Low Voltage Ride Through is an important feature for wind turbine systems. DFIG is sensitive to grid voltage variations. To overcome this, suitable control must be implemented to protect the converter from tripping during grid voltage faults. The voltage fluctuations, rotor current, torque variations and dc link voltage fluctuation are caused by high current transient. But this increase cost and complexity of the system. Various types of modifications are done in flux tracking and current feedback technique gives good performance characteristics. Improvement of the LVRT with reduced cost and complexity with good reactive power support during fault can be the further research.

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