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Fault Ride-Through Capability Improve for Fixed Speed Wind Turbine by using Bridge-type Fault Current Limiter

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ABSTRACT: The relations between wind turbines and grid results in rising short circuit level and FRT capacity problem throughout fault situation. In this paper, the bridge type fault current limiter with discharge resistor is used for solve these problem. a particular problem about power converter based WTG's is that measure controller planned for dependable process approximately nominal voltage levels will not work as planned throughout low network voltages that can happen during a fault. An effect of this is really improved converter current, which may lead to converter breakdown. This paper present a nonlinear controller propose for a power converter based WTG that ensure that current levels remain within design limits, even at really reduced voltage levels, thus attractive the WTG's fault ride through capacity.

KEYWORDS: Fault ride through (FRT), Fixed speed wind turbine (FSWT), Induction generator (IG), Bridge type fault current limiter

I. INTRODUCTION

Fault ride-through (FRT) is now required for connection of large wind farms in most power systems. The FRT-compliant wind farm must remain connected and actively contribute to system stability during a wide range of network fault scenarios.FRT is particularly important in securing stability in regions where wind is becoming a significant contributor to the power system's dynamic performance.FRT performance requirements differ according to the dynamic characteristics of the power system concerned. Smaller power systems, with little or no interconnection, are more prone to frequency instability, and hence, their Codes typically emphasize the provision of active power. Ireland, with a maximum system demand of 6 GW, represents a small, near-isolated national system with a challenging requirement to restore power within one second of fault clearance. Great Britain, with a maximum demand of 60 GW, represents a larger near-isolated system with similar requirements. In contrast, frequency stability in continental European countries such as Germany is strengthened by interconnections within the Union for the Co-operation of Transmission of Electricity (UCTE).[3]

WIND TECHNOLOGY ENHANCEMENTS TO MEET FRT CHALLENGE

Type	FRT enhancement
A	Dynamic reactive power compensation (RPC)
B	As above + pitch control
C	Rotor converter protection + pitch control
D	Pitch control + braking resistors on dc link

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The wind industry has responded to the introduction of FRT requirements in several ways according to wind turbine technology type. For the purpose of considering FRT response, it is convenient to categorize commercial wind turbines in four main types:
A) Fixed speed wind turbine (FSWTs) with fixed pitch;
B) FSWTs with variable pitch (active stall);
C) Variable speed wind turbines (VSWTs) with doubly-fed induction generator (DFIGs);
D) VSWTs with fully rated converters.

Type A WTs were dominant in the 1990s but now retain less than 1% of the world market share. Type B WTs have retained a sizeable market share and have accumulated an installed world capacity of approaching 10 GW. Type C has been the dominant technology since about 2002, but type D may challenge this dominance in the future as the cost of power electronics continues to fall.
Detailed technical developments, made in reaction to FRT requirement of both FSWT and VSWT, can be characterized as follows:
1)Dynamic reactive power compensation (RPC) by using FACTS device such as SVC and STATCOM
2)Pitch control
3)Rotor converter protection by crowbar resistor
4)Brake resistor.

II. LITERATURE SURVEY

The relations linking wind turbines and grid have been extensively investigated in recent years. Two main problems during the fault situation are the short-circuit level increase and fault ride-through (FRT) ability decrease. The relationship of wind turbines to the grid causes the fault current level raise beyond capability of live equipments in some point of grids. This not only may damage the series equipments but also can reason negative effect on FRT ability of wind turbines. The reply of the wind engineering to FRT wants differ according to wind turbine technology. There are two main types of wind turbines used nowadays: the fixed-speed wind turbine (FSWT) and the variable-speed wind turbine (VSWT). Recent wind turbine generation systems are usually VSWT. But, over the former years, FSWTs have been installed in large scope in power grid. This all discuss by M. Firouzi and G. B. Gharehpetian. [1]

In this paper, the impact of better saturation of DFIG based WTGs on small signal stability and transient stability is examine for a large system. In order to examine the contact on small signal constancy, a logical approach to join point the impact of increased saturation of DFIGs on electromechanical modes of fluctuation using eigen value sensitivity to inertia is developed. The understanding of the real part of the eigen value with respect to inertia evaluate for a system where the DFIGs at their considered addition points in the network are replace by equivalent round rotor synchronous machines provide a good metric to evaluate the impact due to improved DFIG saturation on system dynamic presentation. Both harmful and helpful impact of increased DFIG saturation can be known. The eigen value compassion analysis together with the detailed eigen value study accepted out. This all discussed by Durga Gautam, Student Member, IEEE, Vijay Vittal, Fellow, IEEE, and Terry Harbour, Member, IEEE. [2]

Fault ride-through (FRT) is necessary for large wind farms in most power systems. Fixed speed wind turbines (FSWTs) are a fading but important sector in the fast-growing wind turbine (WT) promote. The series dynamic braking resistor (SDBR) dissipate active power and boost generator voltage potentially displace the need for pitch control and dynamic RPC. This paper uses a diplomat wind farm model to study the beneficial effect of SDBR compared to dynamic RPC. This all concluded by Andrew Causebrook, David J. Atkinson, and Alan G. Jack.[3]

III. SCOPE OF RESEARCH

The relations between wind turbines and grid have been widely investigated in current years. some generator types are in use for wind power application nowadays. The main difference can be made between fixed speed and variable speed wind generator types. Variable speed wind power generation skill encompasses the operation of wind turbines at most favourable power coefficient for a wide wind speed variety. The two most widely used variable speed wind generator concepts are the converter driven synchronous generator and the DFIG. The DFIG is a wound rotor induction generator with a voltage source converter connected to the slip-rings of the rotor. The stator winding is attached directly to the grid and the rotor winding is associated to the grid via a power electronic converter. For power system immovability study, model of a DFIG should be careful for steady state analysis as well as for large trouble dynamic investigation. Even though the wind turbines are circulated within the wind farm, the mass power from the latter is related to the grid at a lone substation. As a result, WTGs within the farm are aggregate into a single unit having an MVA rating equal to the outline of the MVA rating of the individual units. Also, as DFIG units have reactive power ability, the wind farm is modeled in a way parallel to the usual generator for steady state analysis and is represent as a PV bus with suitable VAr limits. Some components that give to the dynamic performance of a DFIG are outline as follows and included in the analysis conduct turbine aerodynamics;

a) Turbine mechanical control (also called pitch control) that controls the mechanical power delivered to the shaft;
b) Shaft dynamics model as a two mass shaft, one mass represent rotor/turbine blades and the second represent the generator;
c) Generator electrical characteristics—as the rotor side converter drives the rotor current very fast, the rotor flux dynamics is ignored and the model behaves as a controlled current source;
d) Electrical controls—three controllers are used to give controls for frequency/active power, voltage/reactive power, and pitch angle/mechanical power;
e) Protection relay settings. [2]

IV. PROPOSED METHODOLOGY AND DISCUSSION

The use of shunt FACTS controllers to improve the fault ride-through of induction generators (IGs) by RPC. The RPC method, which can be provide by STATCOM and SVC, can only control the reactive power after fault happening. Thus, the RPC method is able only to reduce voltage fluctuations of the IG after fault happening [5]. The pitch control system is the cheapest key for the wind generator stabilization, but its reply is slow. As a result, the pitch control system cannot be considered as a useful stabilization means for wind energy conversion system (WECS). In series dynamic braking resistor (SDBR) has been standard and used as a gainful calculate for the improvement of FRT. In direct link of SDBR and dynamic RPC has been represent. The simulation results conclude that a 0.05 per unit (p.u.) SDBR is equivalent to 0.4 p.u dynamic RPC. It means that the SDBR is more helpful than RPC. A significant mean issue for SDBR is its quick addition and early switch out of the dynamic resistor. The bridge-type fault current limiter (FCL) with discharge resistor is used for solving trouble of the interface of WECS and power grid. The increase of the fault current is limited by dc reactor without any wait. This characteristic of the bridge-type FCL suppress the immediate voltage drop and it is able to develop transient performance of WECS in fault instant, which is the main advantage of the bridge-type FCL to other FRT improvement techniques. On the other hand, the discharge resistor of the bridge-type FCL aims to raise the voltage at the terminals of the generator, thereby justifying the destabilize electrical torque and power during the fault. The WECS is careful as a fixed-speed system able to with a squirrel-cage IG. The simulation results show that not only the fault current is limited but also FRT ability of WECS is improved. Also, a relative study of bridge-type FCL and SDBR for improving FRT ability is accepted out. [1]

V. EXPERIMENTAL RESULTS WITH TABLES AND GRAPHS

5.1:- Simulated power system

A single line diagram of power system with FCL is shown in Fig.2. The parameter of this system is listed in Table

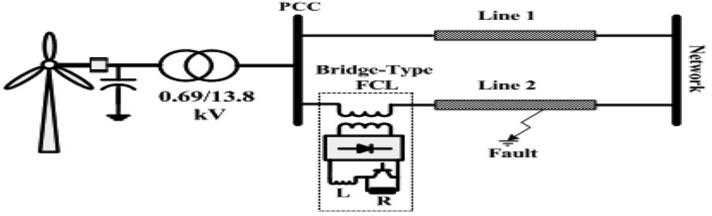

Fig.2:-Simulated power system

A three-phase short-circuit fault is simulated on transmission line 2 (L2), which starts at t = 2 s. After 200 ms, the circuit breaker cut off the faulted line. The voltage verge of the terminal of the IG is equal to the 0.9 p.u. A capacitor bank of 200 kVAR is connected to the terminal of the IG to balance the steady-state reactive power demand for IG. [1]

5.2:- With and without using bridge type FCL

The simulations are carried out for following cases:
1) Case 1: Without using any FCL
2) Case 2: By using the bridge-type FCL and resistor

Parameters		Value
Grid	Supply	13.8 kV
	Frequency	50Hz
	X/R ratio	5
	Transformer	0.69V/13.8 kV 1 MVA
Line	R	0.1(Ω/km)
	X	0.2(Ω/km)
	Length of Line1 (L_1)	20 km
	Length of Line2 (L_2)	20 km
Induction Generator	Power	500 kW
	Voltage	690 V
	Frequency	50 Hz
	Number of poles	4
	Slip	1/8 %
	Power factor	0.88
	Stator resistance	0. 00577 Ω
	Stator reactance	0.0782 Ω
	Rotor resistance	0. 0161 Ω
	Rotor reactance	0.1021 Ω
	Magnetizing reactance	2.434 Ω
FCL	DC reactor (L_d)	0.1 H
	Discharging Resistor (R)	20 Ω

Table:-PARAMETERS OF TEST SYSTEM

5.3:- Simulation Results

A single line diagram of power system with FCL is shown in Fig. 2. The parameter of this system are listed in Table. A three-phase short-circuit fault is simulated on transmission line 2 (L2), which starts at t = 2 s. After 200 ms, the circuit breaker cut off the faulted line. The voltage threshold of the terminal of the IG is equal to the 0.9 p.u. A capacitor bank of 200 kVAR is connected to the terminal of the IG to compensate the steady-state reactive power demand for IG With and Without Using Bridge-Type FCL. The simulations are carried out for following cases:
1) Case 1: Without using any FCL;
2) Case 2: By using the bridge-type FCL and resistor.

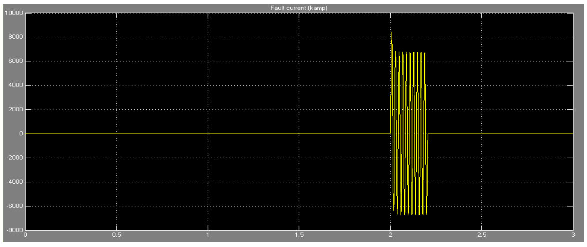

Fig 3:- Fault current without using FCL

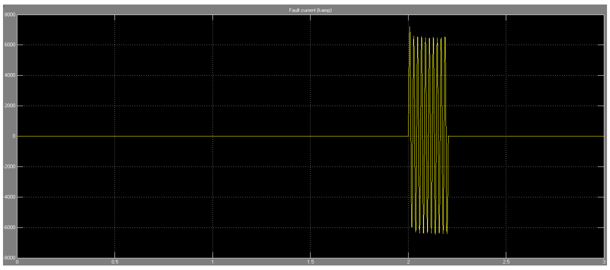

Fig 4:- Fault current with using FCL

In the case 1, the fault current increases to the peak value of 8 kA, approximately. By using the bridge-type FCL, the fault current is limited to the peak value of 6.3 kA.

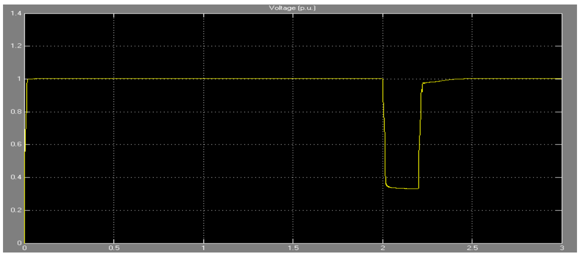

Fig 5:- Voltage drop without using FCL

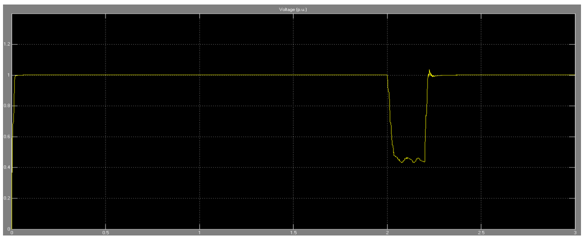

Fig 6:- Voltage drop with using FCL

Fig. 5 and 6 shows the rms value of the point of common coupling (PCC) voltage in both cases. It can be observed that in case 1 the PCC voltage decreases to zero approximately. The bridge-type FCL not only reduces the voltage sag to 0.5 p.u., but also prevents immediate voltage sag at the fault immediate and the voltage recovery process is superior.

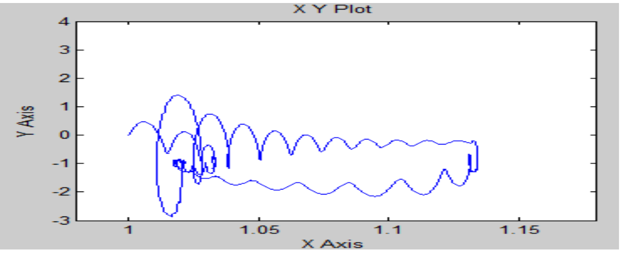

Fig 7:- Electrical torque versus speed without using FCL

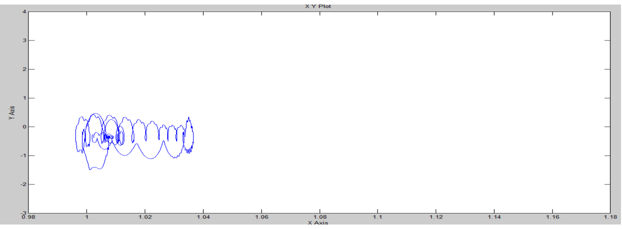

Fig 8:-Electrical torque versus speed with using FCL

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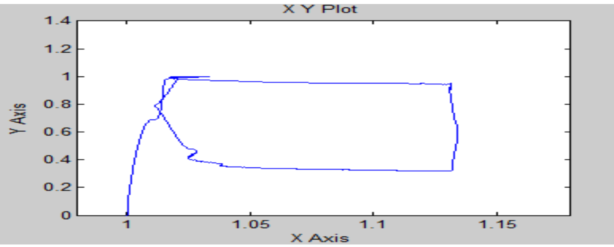

Fig 9:-Voltage versus speed without using FCL

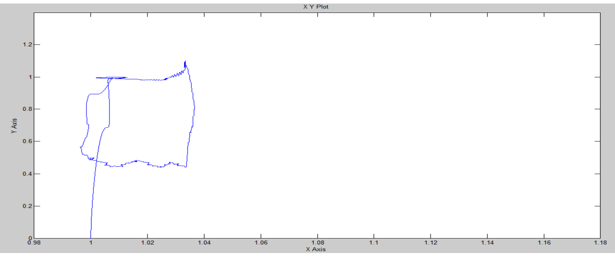

Fig 10:- Voltage versus speed with using FCL

Figs. 7, 8, 9 and 10 show the electrical torque and voltage versus rotor speed, respectively. It can be seen that FCL prevent from voltage sag and rotor increase of rate throughout the fault. According to the electrical torque is proportional to the square of the terminal voltage and inversely proportional to slip and rotor speed. Therefore, these results in decreasing the electrical torque and accelerate the rotor during the fault and thus getting better the stability of IG.

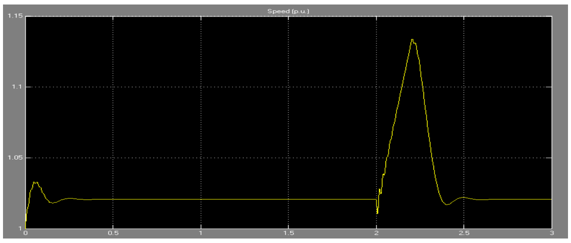

Fig 11:-Rotor speed of induction generator without using FCL

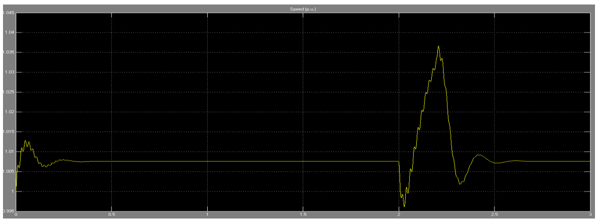

Fig 12:-Rotor speed of induction generator with using FCL

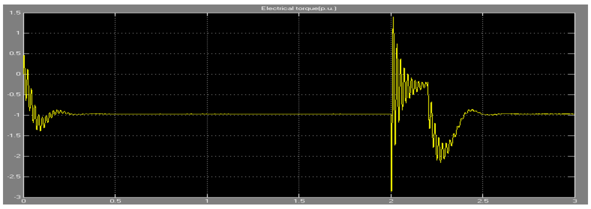

Fig 13:- Electrical torque of induction generator without using FCL

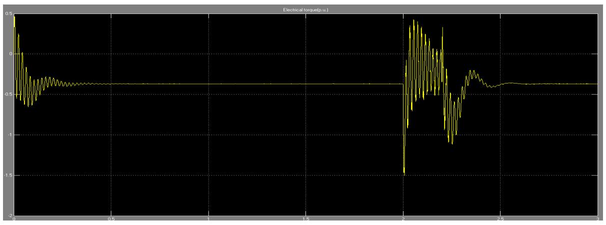

Fig 14 :- Electrical torque of induction generator with using FCL

Figs. 11,12 ,13 and 14 shows the rotor speed of the IG and the electrical torque, respectively. As shown in Fig. 13 and 14 the generator rotor speed swings are reduced in case 2 effectively. These results show that the bridge-type FCL with discharging resistor can provide an effective damping to the post-fault oscillations. shown in Fig. 7 and 8 the variation of the electrical torque is reduced in case 2. The bridge-type FCL is very effective in suppressing the variations of the electrical torque during the fault and swings after fault clearing.

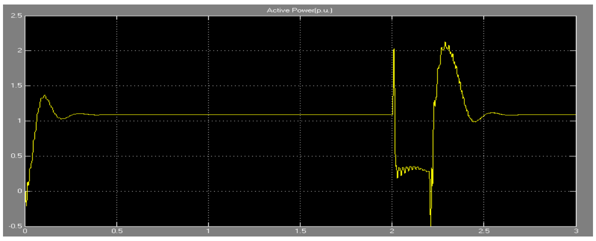

Fig 15:- Active power variations without using FCL

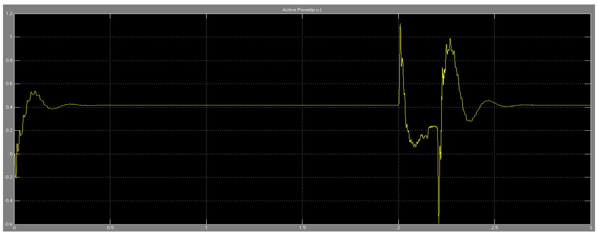

Fig 16:- Active power variations with using FCL

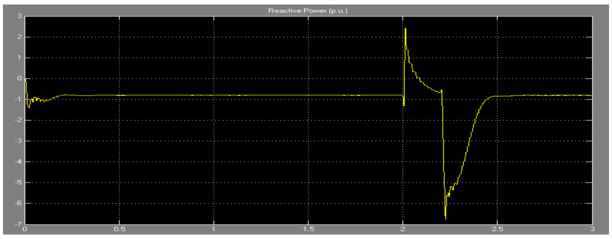

Fig 17:- Reactive power variations without using FCL

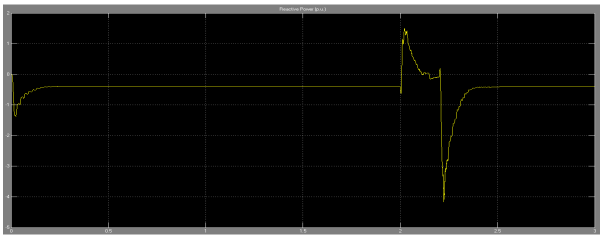

Fig18:-Reactive power variations with using FCL

Figs. 15, 16, 17 and 18 show the total active power generated by the induction generator and the total reactive power exchange between the Induction generator and the grid, respectively. During the fault (2 s < *t* < 2.2 s), the active power generated by the Induction generator is significantly reduced by using the bridge-type FCL, as shown in Fig. 17 and 18. However, compared with the case 1, the IG delivers more active power to the power grid in case 2, and the reactive power absorbed by the Induction generator is reduced, which helps to avoid other problems such as voltage collapse and recovery process.

VI. CONCLUSIONS

Improve the fault ride through performance of a representative large wind farm comprising fixed speed wind turbines. centralized or distributed SDBR is capable of transforming an unstable wind farm response into a comfortably stable one without the need for pitch control or dynamic RPC. This improvement is achieved over an extensive range of balanced and unbalanced faults as typically specified by grid codes.

In this paper, the application of the bridge type FCL, which has a control scheme based on dc reactor current measurement, has been proposed for improving maintain grid stability and capability of FSWT and limiting the fault current. Based on simulation results of a system with an FSWT and the bridge type FCL.

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