Review: Bridge Type Fault Current Limiter for Fixed Speed Wind Turbine to Improving Grid Stability & Capability

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Abstract - *The interaction between wind turbines and grid result in rising short-circuit level and fault ride through (FRT) capability problem throughout fault situation. In this project, the bridge type fault current limiter (FCL) with discharge resistor is used for solve these trouble. For this FCL, a control system is planned, which use the dc reactor current as control changeable, to change the terminal voltage of induction generator (IG) without measure any parameter of scheme. In this project, the wind energy conversion system (WECS) in a fixed speed system equipped with a squirrel- cage IG. The drive train is representing by a two mass model. The simulation study of the bridge type FCL and projected control system for restraining the fault current and recovering FRT ability are offered and compare with the force of the request of the series dynamic braking resistor (SDBR). A new control strategy for improving grid stability and capability of wind farms composed of fixed speed wind turbine generator.*

Key Words: Bridge type fault current limiter (FCL), Induction generator (IG), Fixed speed wind turbine (FSWT), Fault-ride through (FRT), Series dynamic braking resistor (SDBR).

1.INTRODUCTION

The inter connection between grid and wind turbine has been extensively investigate in recent years. Two main problems during the fault condition are the short-circuit level increases and fault ride-through (FRT) capacity decrease. The relationship of wind turbines to the grid causes increase in the fault current level of live equipments in some points of grids. This not only capacity damage to the series equipments but also can reason for harmful effect on FRT capacity of wind turbines. The reaction of the wind industry to FRT requirements differ according to wind turbine technology. There are two main types of wind turbines used today: the fixed-speed wind turbine (FSWT) and the variable-speed wind turbine (VSWT). New wind turbine generation systems are regularly VSWT. But, over the former years, FSWTs have been installed in large size in power grids. Particular technical development made in reply to FRT wants of both FSWT and VSWT, can be considered as follows:

1) Dynamic Reactive Power Compensation (RPC) by means of FACTS device such as SVC & STATCOM
2) Pitch Control
3) Series Dynamic Braking resistor (SDBR)

We know the application of shunt FACTS controller to progress the fault ride-through of Induction generators (IGs) by Reactive Power Compensation (RPC). The RPC method, which can be providing by STATCOM and SVC, can only control the reactive power after fault had happen. Thus, the RPC method is capable only to reduce voltage fluctuations of the IG after fault occur. 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 consider as an valuable stabilization means for wind energy conversion system (WECS).Series dynamic braking resistor (SDBR) has been acknowledged and used as a commercial measure for the improvement of FRT. An essential design factor for SDBR is its quick addition and early switch out of the dynamic resistor. In the propose thesis, the bridge-type fault current limiter (FCL) with discharge resistor is used for solve trouble of the relations of WECS and power grid. The increase of the fault current is restricted by dc reactor without any hold-up. This quality of the bridge-type FCL suppresses the immediate voltage drop and it is able to recover transitory actions of WECS in fault moment, which is the main advantage of the bridge-type FCL to other FRT improvement technique. On the other hand, the discharge resistor of the bridge-type FCL aim to raise the voltage at the terminals of the generator thereby justifies the destabilize electrical torque and power through the fault. The WECS is considering as a fixed-speed system capable of with a squirrel-cage IG. The model results will show that not only the fault current is restricted but also FRT ability of WECS will improve.

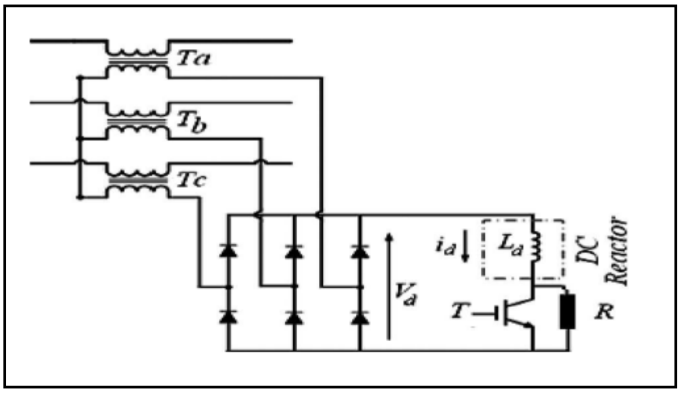

Fig.1.1 Bridge-type FCL with discharging resistor.

As shown in Fig.1.1, the bridge-type FCL with discharge resistor (R) require the combination transformer to be linked to the power grid. The secondary winding of the transformer is a star connected. The dc reactor of FCL is linked to the secondary winding of the series transformer (Ta, Tb, and Tc). The inductance of dc reactor has been modeled by Ld. As shown in Fig.1.1, the parallel relationship of the discharge resistor (R) and semiconductor switch (T) are linked in series with the dc reactor.

The circuit shown in Fig. 1.2 below is used for systematic studies. The source impedance is modeled by $Z_s = R_s + j\omega L_s$. The impedance $Z_L = R_L + j\,\omega L_L$ present the line and load impedance. The transformer is supposed to be ideal and its turn ratio is equal to 1.

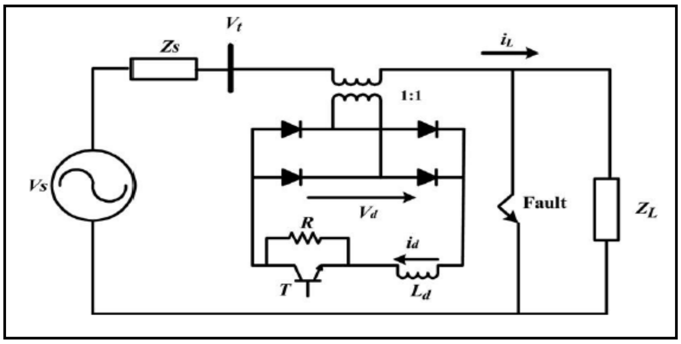

Fig.1.2 Circuit topology for analytical analysis

2. FIXED SPEED WIND TURBINE

FSWT utilize squirrel-cage IG openly connected to the power grid. As the name suggest, FSWTs revolve at almost a constant speed, which is resolute by the frequency of the supply grid, the equipment ratio, and the IG design. The FSWT has the benefit of being easy, healthy, consistent, and well established. Their disadvantages are high preliminary currents and their command for reactive power. This type of turbine also requires a powerful mechanical design to absorb high mechanical stress. [1]

2.1 Wind Speed Model

One move towards to model a wind speed progression is to use capacity. A more flexible advance is to use a wind speed model that can produce wind speed sequence with characteristics to be selected by the user, by surroundings the value of parallel parameter to an suitable value. The wind speed is modeled as the sum of vwa(t) base wind speed, vwg (t) gust wind speed, vwr (t) ramp wind speed, and vwt(t) noise wind speed, as shown in Fig.2.1, and expressed by the following equation:

vw(t) = vwa(t) + vwr(t) + vwg(t) + vwt(t)......................... (1)

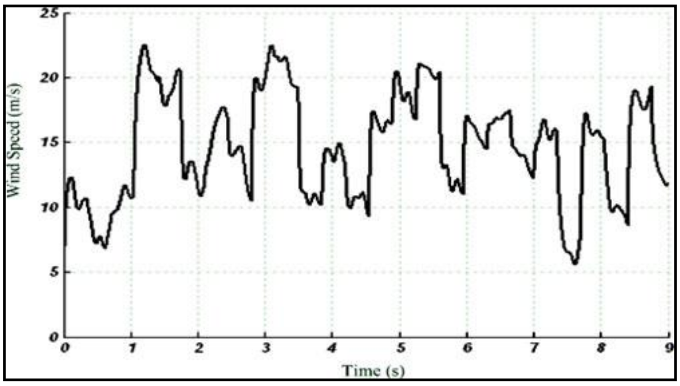

Fig. 2.1 Wind speed model.

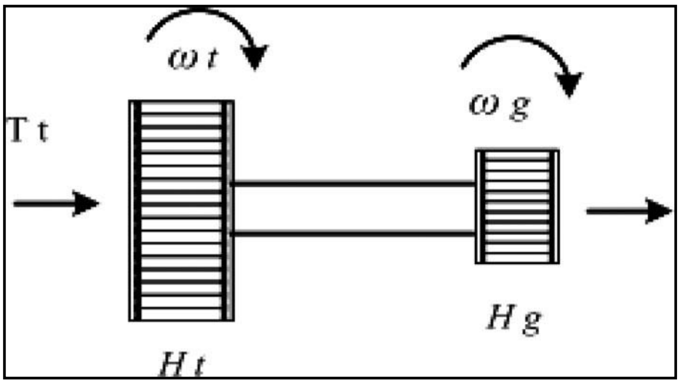

Fig. 2.2 Two mass model of wind turbine train

2.2 Wind Turbine Model

In general, the relative between wind speed and mechanical power extracted from the wind
can be describe as follow

$Pwt = \rho/2AwtCp\,(\lambda, \theta)v3w$.. (2)

Where Pωt is the power extracted from the wind,
ρ the air density,
vω is the wind speed,
CP the performance coefficient or power coefficient,
λ the tip speed ratio,
Aωt = πR2 the area covered by the wind turbine rotor,
and R is the radius of the tip speed ration.

λ is defined as follows:

$\lambda = R\omega r/v\omega$ .... (3)

where ωr is the angular mechanical speed. The performance coefficient is different for each
turbine and is relation to the tip speed ratio λ and pitch angle β. In this study, the Cp is as
follow:

$CP = 1/2(\lambda - .022\beta 2 - 5.6)\, e{-0.17\lambda}$.. (4)

2.3 Drive Train System

The shaft model of the wind turbine is describe by the two mass model, as shown in Fig.2.3,

and is defined as follows:

$\partial\theta s/\partial t = \omega t - \omega g$ -- (5)

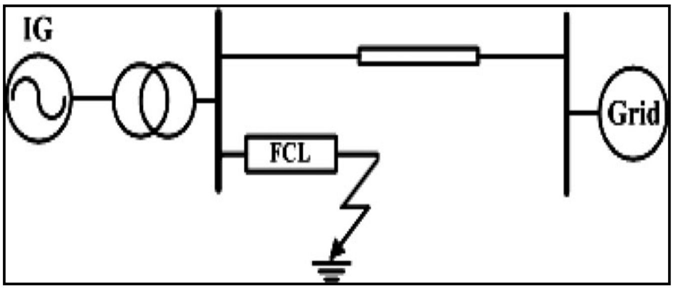

Fig.2.3 Equivalent circuit of power system.

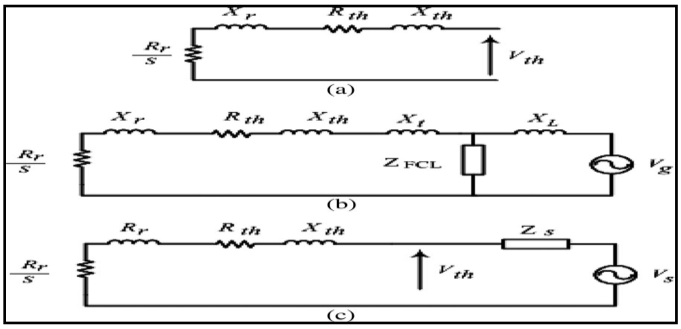

Fig.2.4 (a) Steady-state equivalent circuit of induction generator. (b) Equivalent circuit of system with FCL during fault. (c) Equivalent circuit of system seen from IG terminals.

3. PROPOSED METHODOLOGY

The use of shunt FACTS controllers to improve the fault ride through of induction generators by RPC. The RPC method, which can be provide by STATCOM and SVC, can only the reactive power after fault happening. Thus, the RPC method is able only to reduce voltage fluctuations of the IGs after fault happening [5].

A] Without and With Using Bridge-Type FCL

1) Case 1: Without using any FCL;
2) Case 2: By using the bridge-type FCL and resistor.

B] With using SDBR and Bridge-Type FCL

C] Comparison Between Portrayed Technologies

4. CONCLUSION

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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