

# The Voltage Stability Research of DFIG Connected to Receiver System

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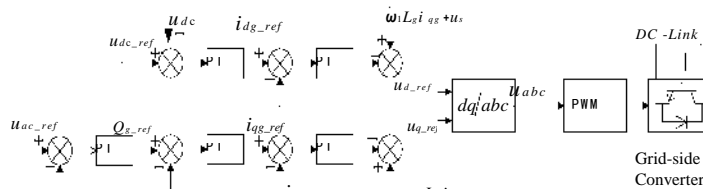
**Abstract.** This paper uses DIgSILENT/PowerFactory to research the voltage stability when the doubly-fed induction generator (DFIG) is connected to the receiver system. In order to analyze the transient voltage stability, this paper researches the critical clearing time of the system. At last, in order to improve the transient voltage stability of the system, static synchronous compensator (STATCOM) is installed at the point of common coupling (PCC). This paper also researches the coordinated control strategy between DFIG and STATCOM.

**Keywords:** DFIG, PV curve, critical clearing time, STATCOM, coordinated control

## 1 Introduction

Analysis and control of DFIG model adopts vector control method. For the rotor side, using the method of stator-flux oriented, ignore the rotor transient and resistance<sup>[1]</sup>. The result indicates that the proposed control scheme achieves decoupled control between active power and reactive power at stator side.

In general, unity power factor control method is used to control the grid side converter. In this paper, double closed-loop which consists of outer voltage loop and inner current loop is used. When a fault happens, this control can adjust voltage in time according to the voltage fluctuation. Put the difference between the actual output and the expected value into PI controller and then the reactive reference is gained. Considering the above analysis, block diagrams of vector control scheme for the grid side converter can be gained, as shown in figure 1.



**Fig.1.** Block diagrams of vector control scheme for the grid side converter

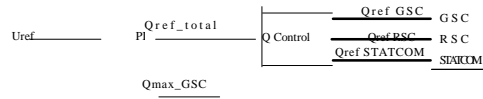
## 2 The Theory of Coordinated Control and Example Analysis

This paper researches the coordinated control strategy between DFIG and STATCOM. When the reactive power demand is still unable to meet, the STATCOM will provide reactive power support. The operation of Crowbar can cause the rotor side converter to quit. And the grid side converter and STATCOM provide reactive power support.

The main consideration is rotor side converter current limiting:

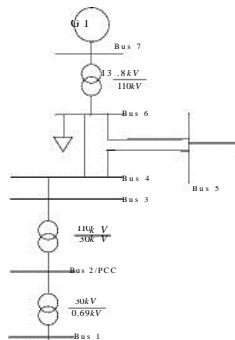
$$\sqrt{3}U_s \left( \frac{Q_s}{P_s} + \omega L_m \right) \leq I_{r,max} \quad (1)$$

$Q_s$  is the reactive power from the stator side.



**Fig.2.** Schematic diagram of coordinated control

In figure 2,  $U_{ref}$  is the voltage reference at point of common coupling;  $Q_{ref\_total}$  is the total reactive defect value of the system;  $Q_{max\_GSC}$  is the maximum of reactive power of grid side converter;  $Q_{ref\_GSC}$ ,  $Q_{ref\_RSC}$  and  $Q_{ref\_STATCOM}$  is the reactive



power reference of GSC, stator side and STATCOM respectively.

The simplified diagram of the example system is shown in figure 3.

**Fig.3.** The simplified diagram of the example system

Synchronous motor adopts non-salient pole generator model. Load adopts constant power model. DFIG wind turbines adopt simple parallel wind farm. There are 22 wind turbines and each capacity is 2.22 MW. The other simulation parameters of DFIG are shown in table 1.

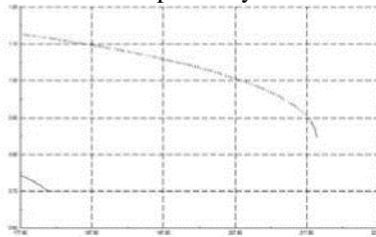
**Table 1.** Parameters of DFIG

Parameter	Value	Parameter	Value
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Stator voltage	3.3kV	Stator resistance	0.0029p.u.
DC bus voltage	1.15kV	Stator reactance	0.125p.u.
DC-side capacitance	4.81uF	Rotor resistance	0.004p.u.
Reactor inductance	0.24mH	Rotor reactance	0.05p.u.
Stator mutual inductance	2.5p.u.	Inertia	101.7 kgm <sup>2</sup>

### 3 Voltage Stability Analysis of Receiver System

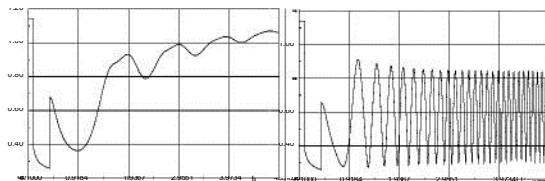
PV curve changes before and after DFIG connected with PCC, as is shown in figure 4. The dotted line and solid line represents the changes when PCC point connected with the synchronous generator and DFIG respectively.



**Fig.4.** PV curve at PCC

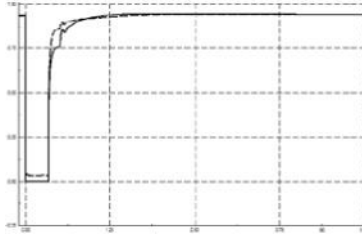
The voltage range is from [0.848p.u.to](#) 1.125p.u.when the PCC point connected with synchronous generator. After DFIG is connected, the range is from [0.701p.u.to](#) 0.742p.u. . The stable operation region is smaller and the system becomes unstable.

This paper analyses the changes of critical clearing time before and after DFIG connected with PCC.



**Fig.5.** Critical clearing time at PCC connected with synchronous generator

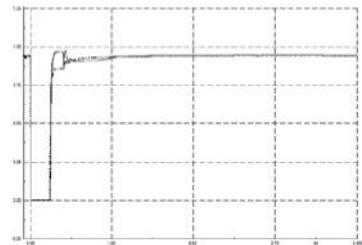
The figure 5 reveals that the grounding resistance is zero and the failure time is set to 0.33s and 0.34s respectively. The critical clearing time is 0.33s.



**Fig.6.** Fault waveform at PCC connected with DFIG

In figure 6, the full line gives the fault waveform while DFIG using unity power factor control, the dotted line gives the fault waveform while grid side inverter adopting voltage loop control. After DFIG connected with PCC, the time of three-phase short-circuit grounding fault is set to 0.34s. The grounding resistance is 0. The PCC point has no collapse. After the connection of DFIG, the Crowbar actions, then the rotor side converter is shorted. The stator absorbs reactive power from grid. The phenomenon like generator out-of-step will not happen. But it increases the degree of voltage sags at PCC. The voltage drops to around 0.25p.u. in figure 7. In terms of voltage sags, DFIG in voltage loop control is better than that in unity power factor control. In addition, better recovery of voltage can be obtained after the fault cleared.

On this basis, 20MW reactive compensation device STATCOM is installed. Comparison is made between the following two cases: first, DFIG adopts unity power factor control and the grid reactive power is mainly supported by STATCOM, as is shown by a solid line in figure 9. Second, DFIG adopts variable power factor control and provide reactive power support with STATCOM, as is shown by a dashed line.



**Fig.7.** The voltage waveform at PCC

In terms of figure 7, the STATCOM can improve the voltage stability. And the coordinated control strategy make the recovery of voltage faster which demonstrates that better transient voltage stability can be obtained, and the system is more stable.

## 4 Conclusion

The simulation result demonstrates that when the doubly-fed induction generator is connected to the receiver system, the voltage stability will be seriously affected. The coordinated control strategy between DFIG and STATCOM can make full use of DFIG reactive power ability, using the minimal of capacity of STATCOM. In addition, the system can recover faster after the fault is cleared.

## References

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