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FSIG 풍력발전의 특성개선을 위한 DFIG의 협조 전압제어

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Coordinated Voltage Control of DFIG to Overcome Shortcomings of FSIG in Wind Turbine System

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Abstract - *At present, the widely used wind power generators in the whole world are fixed speed induction generator (FSIG) and doubly fed induction generator (DFIG). The models of FSIG and DFIG wind power generation system connected with the grid are built, and their steady-state and transient characteristics are studied. A new coordinated control strategy using both the grid and rotor side converters of DFIG for voltage regultation and reactive power support is put forword to improve the steady-state and transient performance of the FSIG in the case of DFIG in parallel with FSIG.*

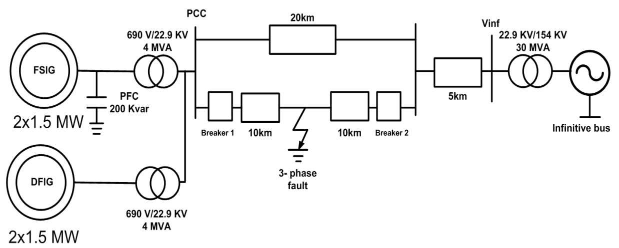
1. INTRODUCTION

The history of wind turbine technology before the year 2000 was dominates by FSIG. This machine uses a squirrel cage induction generator connected directly to the grid through a transformer and has been popular because of its reliability, low cost and robustness, However, a key issue with FSIG is its lack of controllability. It requires reactive power from the grid both during normal operation and particularly after faults on the network, making it susceptible to over-speeding and consequent disconnection, which may contravene grid codes [1]. These issues of grid code compliance have been part of the driving force behind the development of variable-speed technologies, especially the DFIG. The number of installed DFIG wind turbines has been increasing dramatically since 2000 and between 2000 and 2001 it overtook the number of FSIG plants. In the year 2003, more than 50% of installed wind generation used the DFIG, whereas the FSIG share had dropped to under 20% [2]. The rapid growth of DFIG technology has led many cases where these turbines are being installed alongside existing FSIG ones. The ability of the DFIG to provide terminal voltage/reactive power control has been realized [3].

This paper presents a new coordination method for voltage control and reactive power support of DFIG to improve the steady-state and transient performance of FSIG in the case of DFIG in parallel with FSIG. The central idea here is to derive the reactive power reference signal of the rotor side converter (RSC) and grid side converter (GSC) from the point common coupling (PCC) voltage controller.

2. MODEL OF GRID-CONNECTED WIND FARM WITH DFIGs AND FSIGs

The simulated power system is shown in Fig. 1. A 3 MW DFIG wind farm is located close to a FSIG wind farm of the same size. The wind farms are coupled to the PCC through a transformer, while at the terminals of the FSIG there is 200 Kvar PFC.

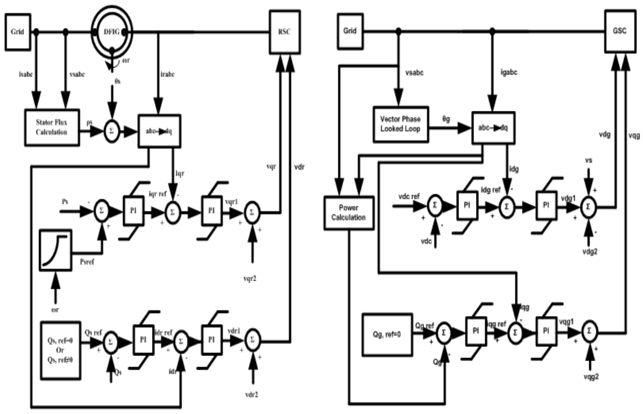


<Fig. 1> Schematic diagram of grid-connected wind generation system

2.1 INDEPENDENT CONTROL STRATEGY OF DFIG

The DFIG control and its performance in independent operation have been discussed in [4]. In independent operation the aim of the RSC is to control independently the active and reactive power on the grid, while the GSC has to maintain the DC link capacitor voltage at a set value regardless of the magnitude and direction of the rotor power and to guarantee converter operation with unity power factor (zero reactive power). The reference signals for controllers in the case of independent control strategy are illustrated in Fig. 2.

The reference Qs,ref for the reactive power of the RSC can be set to a certain value or to zero according to whether or not the DFIG is required to contribute with reactive power. The reactive power reference for the GSC, Qg,ref, is usually set to zero. This means that the GSC exchanges with the grid only active power, and therefore the transmission of reactive power from the DFIG to the grid is done only through the stator.

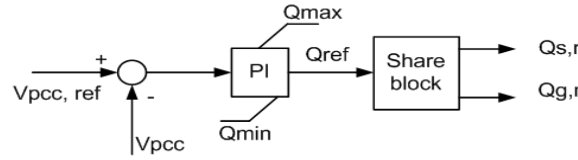


<Fig. 2> Overall vector control scheme of independent DFIG

2.2 COORDINATED CONTROL STRATEGY OF DFIG

Active and reactive power output of the DFIG can be regulated independently. This is a significant advantage since the reactive power can be adjusted independently for voltage control purpose. This paper presents a new coordinated control strategy using both grid and rotor side converters for voltage regulation and reactive power support. The central idea here is to share reactive reference signal from the PCC voltage controller between RSC and GSC.

The voltage control purpose is use as the appropriate reactive power control law in this case, the aim of the reactive power regulation is to obtain a reasonable voltage level at the access point, the coordinated operation strategy shown in Fig. 3. The reactive power value required for voltage regulation can be split between the stator and GSC in a controlled manner.



<Fig. 3> Schematic diagram of coordinated voltage control

3. SIMULATION RESULTS

3.1 STEADY-STATE ANALYSIS

With independent control DFIG, the reactive power at terminal is set to 0. As a result, the FSIG will absorb abundant reactive power from the grid (Fig. 4), DFIG with independent control strategy can not improve weakness of FSIG in parallel. However, we can set coordinated DFIG reactive power reference value from the coordinated control scheme (Fig. 3) as the required reactive power value of FSIG so that provide static and dynamic reactive power support for FSIG. By this way, the reactive power at PCC is nearly 0 (Fig. 5). Comparing fig. 4 and fig. 5, we can see that the coordinated control improve the static and dynamic stability of voltage as soon as reactive power absorption of FSIG from the system significantly.

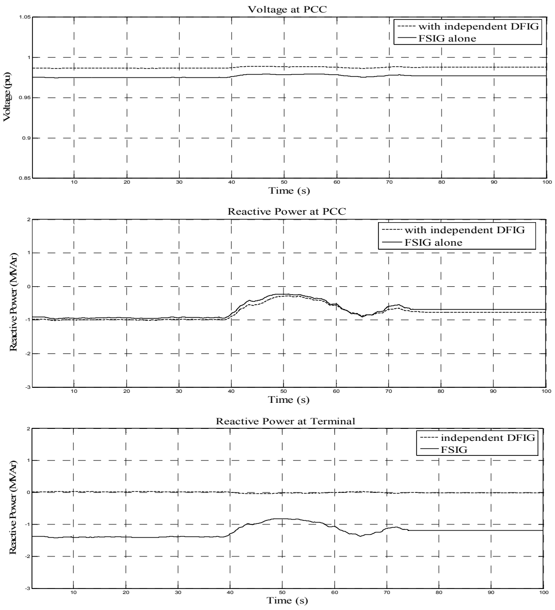
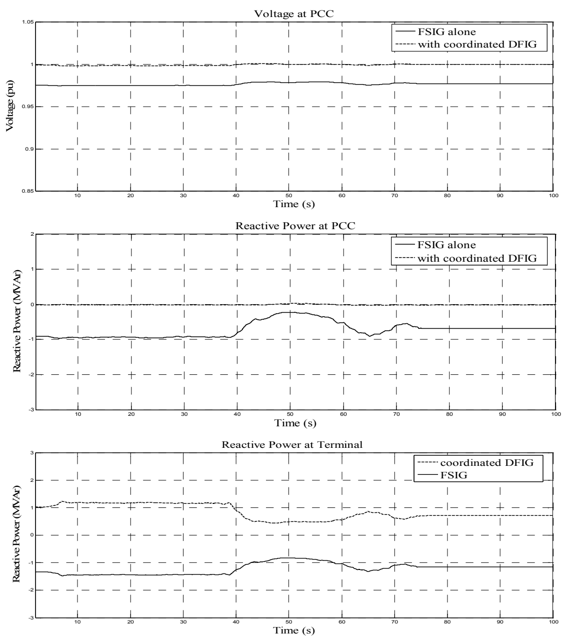


Fig. 4: Independent control during steady-state

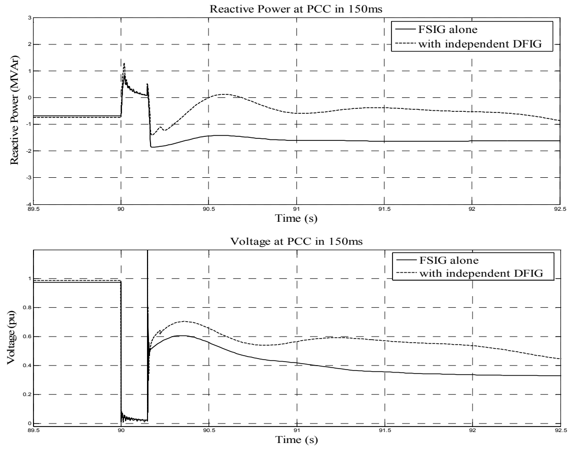


<Fig. 5> Coordinated control during steady-state

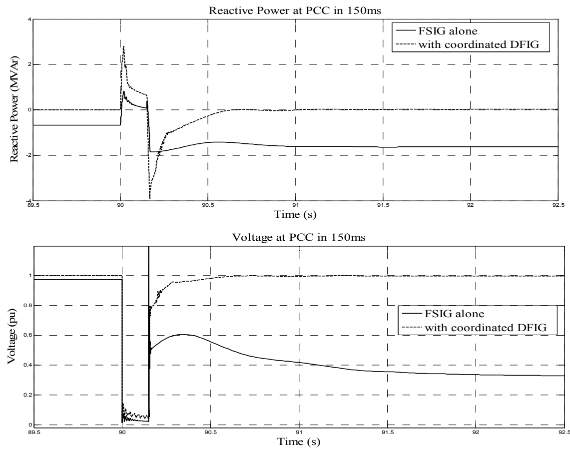
3.2 TRANSIENT-STATE ANALYSIS

The fault event is a three-phase to ground short-circuit fault at the middle of one of the two parallel lines, which begins at 90s After 150ms the fault is cleared.

It can be seen that because of the high reactive power consumption by the FSIG after fault. the AC voltage stays low. With independent DFIG, the system becomes unstable and eventually the PCC voltage collapses and the wind farm has to be disconnected (Fig. 6). However, the system is stable with coordinated DFIG (Fig. 7).



<Fig. 6> Coordinated control during transient performance



<Fig. 7> Coordinated control during transient performance

4. CONCLUSION

This paper has considered a control scheme whereby the DFIG can be exploited to provide extra reactive power support to FSIG-based wind farms, which have no dynamic reactive power or voltage control capability, in critical situations. Simulation results show that the coordinated control scheme, where extra DFIG reactive power is produced, can raise the AC voltage and consequently help the system to recover and improve the stability of the nearby FSIG-based wind farm.

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