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TWO-STAGE INVERTER-& RECTIFIER BASED CONSTANT POWER CONTROL AND FAULT-RIDE-THROUGH ENHANCEMENT OF DFIG WIND TURBINES WITH ENERGY STORAGE AND PSS

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ABSTRACT:

With the increasing penetration of wind power into electric power grids, energy storage devices will be required to dynamically match the intermittency of wind energy. This paper proposes a novel two-layer constant-power control scheme for a wind farm equipped with doubly-fed induction generator (DFIG) wind turbines. To enhance the robustness of stabilizing controllers against system uncertainties, this paper proposes a new coordinated robust control of doubly fed induction generator (DFIG) wind turbine equipped with power oscillation damper (POD) and synchronous generator installed with power system stabilizer (PSS) for stabilization of power system oscillations. Each DFIG wind turbine is equipped with a super capacitor energy storage system (ESS) and is controlled by the low-layer WTG controllers and coordinated by a high-layer wind-farm supervisory controller (WFSC). The WFSC generates the active-power references for the low-layer WTG controllers according to the active-power demand from the grid operator; the low-layer WTG controllers then regulate each DFIG wind turbine to generate the desired amount of active power, where the deviations between the available wind energy input and desired active power output are compensated by the ESS. Simulation studies are carried out in PSCAD/EMTDC on a wind farm equipped with 15 DFIG wind turbines to verify the effectiveness of the proposed control scheme.

INTRODUCTION

Wind turbine generators (WTG) are usually controlled to generate maximum electrical power from wind under normal wind conditions. However, because of the variations of wind speed, the generated electrical power of a WTG is usually fluctuated. Currently, wind energy only provides about 1%–2% of the U.S.'s electricity supply. At such a penetration level, it is not necessary to require WTGs to participate in grid frequency regulation, unit commitment, or to supply a constant amount of active power as required by the grid operator. However, it is reasonable to expect that wind power will be capable of becoming a major contributor to the nation's and world's electricity supply over the next three decades. At require WTGs to participate in grid frequency regulation as well as to supply the desired amount of active power for power flow control. To meet the requirements of frequency and active power regulation, energy storage devices will be required to dynamically match the intermittency of wind energy. In, the authors investigated and compared different feasible electrical energy storage technologies for intermittent renewable energy generation, such as wind power. The use of super capacitors or batteries as energy storage devices for WTGs has been studied by some researchers.

DFIG WIND TURBINE WITH ENERGY STORAGE

Fig.1 shows the basic configuration of a DFIG wind turbine equipped with a super capacitor-based ESS. The low speed wind turbine drives a high-speed DFIG through a gearbox. The DFIG is a wound-rotor induction machine. It is connected to the power grid at both stator and rotor terminals. The stator is directly connected to the grid while the rotor is fed through a variable-frequencydc-link-voltage converter, which consists of a rotor-side converter (RSC) and a grid-side converter (GSC) and usually has a rating of a fraction (25%–30%) of the DFIG nominal power. As a consequence, the WTG can operate with the rotational speed in a range of ±25%–30% around the synchronous speed, and its active and reactive powers can be controlled independently. In this work, an ESS consisting of a super capacitor bank and a two-quadrant dc/dc converter is connected to the dc link of the DFIG converters. The ESS serves as either a source or a sink of active power, and therefore, contributes to control the generated active power of the WTG.

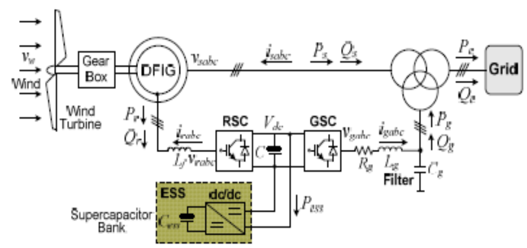

Fig. 1. Configuration of a DFIG wind turbine equipped with a supercapacitor ESS connected to a power grid.

WIND FARM MODEL

Fig. shows the configuration of the wind farm used in this work. It consists of 15 DFIG wind turbines of 3.6 MW power capacity each. The total power capacity of the wind farm is 54 MW. Each DFIG wind turbine is connected to the internal network of the wind farm through a 4.16/34.5-kV voltage step-up transformer.

The high-voltage terminals of all transformers in the wind farm are connected by 34.5-kV power cables to form the internal network of the wind farm. The entire wind farm is connected to the utility power grid through a 34.5/138-kV voltage step-up transformer at the point of common coupling (PCC) to supply active and reactive powers of *P* and *Q*, respectively. In this work, the power grid is represented by an infinite source.

CONTROL OF INDIVIDUAL DFIG WIND TURBINE

The control system of each individual DFIG wind turbine generally consists of two parts: the electrical control of the

DFIG and the mechanical control of the wind turbine blade pitch angle. Control of the DFIG is achieved by controlling the RSC, the GSC, and the ESS The control

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objective of the RSC is to regulate the stator-side active power *Ps* and reactive power *Qs* independently. The control objective of the GSC is to maintain the dc-link voltage *Vdc* constant and to regulate the reactive power *Qg* that the GSC exchanges with the grid. The control objective of the ESS is to regulate the active power *Pg* that the GSC exchanges with the grid.

A. CONTROL OF THE RSC

Fig. shows the overall vector control scheme of the RSC, in which the independent control of the stator active power *Ps* and reactive power *Qs* is achieved by means of rotor current regulation in a stator-flux oriented synchronously rotating reference frame. Therefore, the overall RSC control scheme consists of two cascaded control loops. The outer control loop regulates the stator active and reactive powers independently, which generates the reference signals *idr ** and *iqr ** of the *d*-axis and *q*-axis current components, respectively, for the inner-loop current regulation.

The outputs of the two current controllers are compensated by the corresponding cross-coupling terms *vdr*0 and *vqr*0 , respectively, to form the total voltage signals, *vdr* and *vqr*. They are then used by the PWM module to generate the gate control signals to drive the RSC. The reference signals of the outer-loop power controllers are generated by the high-layer WFSC.

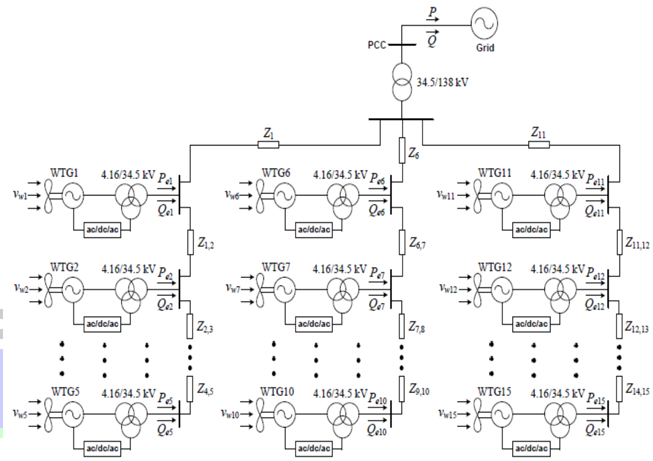

Fig. 2. Configuration of a wind farm equipped with 15 DFIG wind turbines connected to a power grid.

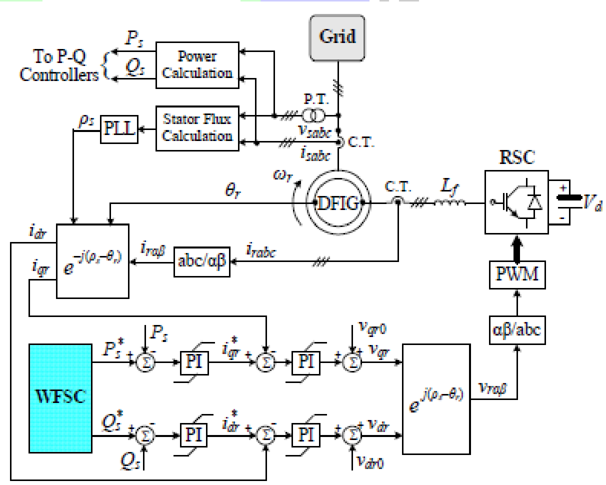

Fig. 3. Overall vector control scheme of the RSC.

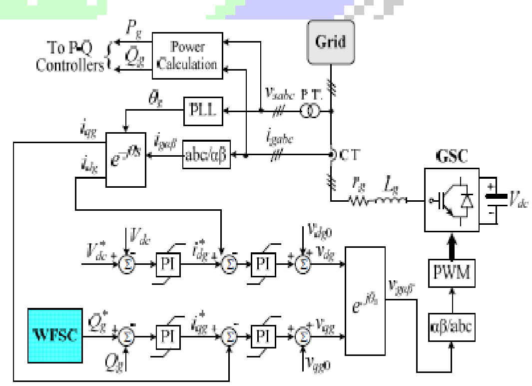

Fig. 4. Overall vector control scheme of the GSC.

B. CONTROL OF THE GSC

Fig. shows the overall vector control scheme of the GSC, in which the control of the dc-link voltage *Vdc* and the reactive power *Qg* exchanged between the GSC and the grid is achieved by means of current regulation in a synchronously rotating reference frame. Again, the overall GSC control scheme consists of two cascaded control loops. The outer control loop regulates the dc-link voltage *Vdc* and the reactive power *Qg*, respectively, which generates the reference signals *idg* * and *iqg* * of the *d*-axis and *q*-axis current components, respectively, for the inner-loop current regulation. The outputs of the two current controllers are compensated by the corresponding cross-coupling terms *vdg*0 and *vqg*0, respectively, to form the total voltage signals, *vdg* and *vqg*. They are then used by the PWM module to generate the gate control signals to drive the GSC. The reference signal of the outer-loop reactive-power controller is generated by the high-layer WFSC

C. CONFICURATION AND CONTROL OF THE ESS

Fig. illustrates the configuration and control of the ESS. The ESS consists of a super capacitor bank and a two- quadrant dc/dc converter connected to the dc link of the DFIG. The dc/dc converter contains two IGBT switches S1 and S2. Their duty ratios are controlled to regulate the active power *Pg* that the GSC exchanges with the grid.

In this configuration, the dc/dc converter can operate in two different modes, i.e., buck or boost mode, depending on the status of the two IGBT switches. If S1 is closed and S2 is open, the dc/dc converter operates in the buck mode; if S1 is open and S2 is closed, the dc/dc converter operates in the boost mode. The duty ratio *D*1 of S1 can be approximately expressed as

$$D_1 = \frac{V_{SC}}{V_{dc}} \qquad (1)$$

and the duty ratio *D*2 of S2 is *D*2 = 1 – *D*1. In this paper, the nominal dc-voltage ratio *VSC,n*/*Vdc,n* is 0.5, where *VSC,n* and *Vdc,n* are the nominal voltages of the super capacitor bank and the DFIG dc link, respectively. Therefore, the nominal duty ratio *D*1,*n* of S1 is 0.5. The duty ratio *D*1 of the dc/dc converter is controlled depending on the relationship between the active powers *Pr* of the RSC and *Pg* of the GSC. If *Pr* is greater than *Pg*, *D*1 is controlled greater than 0.5. Consequently, the super capacitor bank serves as a sink to absorb active power, which results in the increase of its voltage *VSC*. On the contrary, if *Pg* is greater than *Pr*, *D*1 is controlled less than 0.5. Consequently, the super capacitor bank serves as a source to supply active power, which results in the decrease of its voltage *VSC*. Therefore, by controlling the duty ratio of the dc/dc converter, the ESS serves as either a source or a sink of active pow er to control the generated active power of the WTG. In Fig. 5, the reference signal *Pg* * is generated by the high-layer WFSC

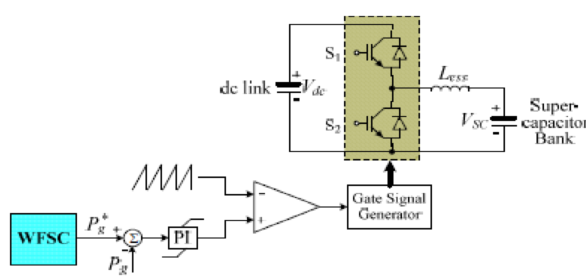

Fig. 5. Configuration and control of the ESS.

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SIMULATION DESIGN & CASE STUDY

CASE:I

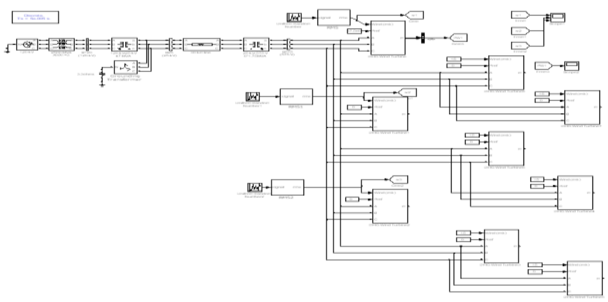

Fig.6 Simulink model of DFIG wind_constantpower1

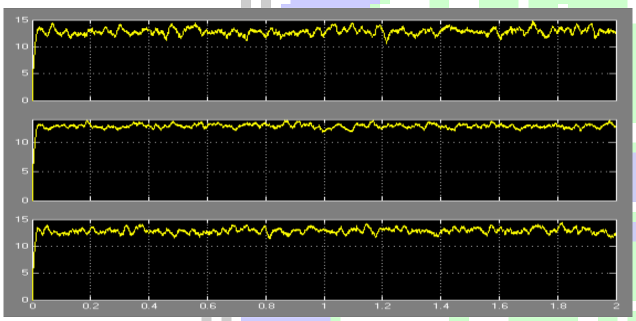

Fig.7 wind speeds of turbines

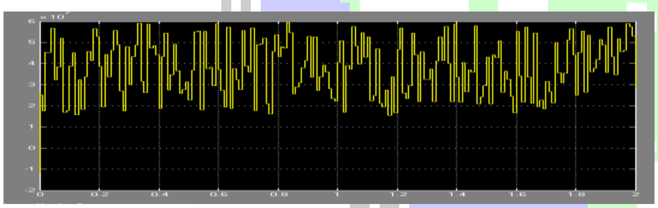

Fig.8 DFIG wind turbine power

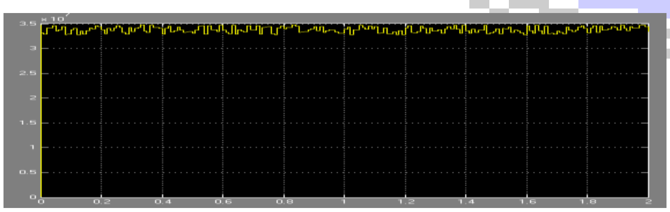

Fig.9 Active & reactive power b575

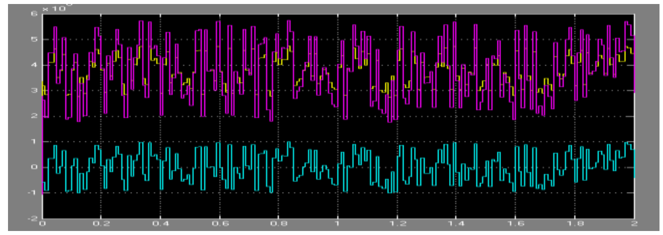

Fig.10 Active & reactive power of wind turbine1

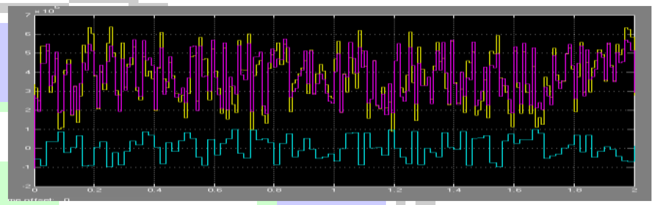

Fig.11 Active & reactive power of wind turbine2

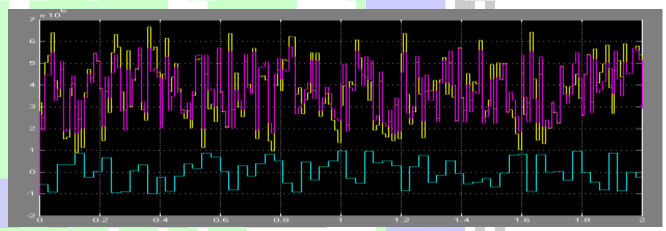

Fig.12 Active & reactive power of wind turbine3

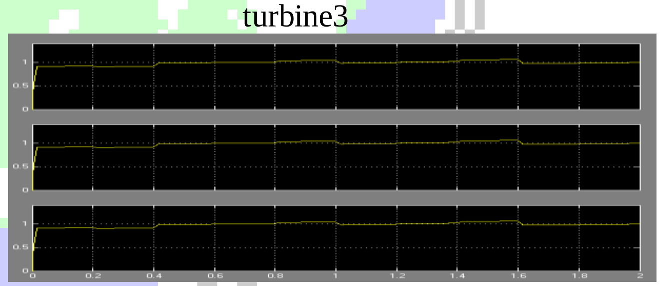

Fig.13 voltages of wind turbines 1,2,3

CONCLUSION

This paper has proposed a novel two-layer CPC scheme for a wind farm equipped with DFIG wind turbines. Each wind turbine is equipped with a super capacitor-based ESS, which is connected to the dc link of the

DFIG. The ESS and the controllers of each individual DFIG wind turbine have been suitably designed. A high-layer WFSC has been developed to coordinate the actions of the low-layer individual WTG controllers. Consequently, the wind farm generates constant active power as required by the grid operator. Simulation studies have been carried out on a wind farm equipped with 15 DFIG wind turbines to verify the effectiveness of the proposed CPC scheme. Results have shown that the proposed CPC scheme enabled the wind farm to actively participate in active power regulation of the grid. The proposed system and control scheme provides a promising solution to help achieve high levels of penetration of wind power into electric power grids

REFERENCES:

[1] "Focus on 2030: EWEA aims for 22% of Europe's electricity by 2030," Wind Directions, pp. 25-34, Nov./Dec. 2006.

[2] "20% wind energy by 2030: increasing wind energy's contribution to U.S. electricity supply," U.S. Department of Energy, July 2008.

[3] W. Qiao and R. G. Harley, "Grid connection requirements and solutions for DFIG wind turbines," in Proc. IEEE Energy 2030 Conference, Atlanta, GA, USA, Nov. 17-18, 2008.

[4] J. P. Barton and D. G. Infield, "Energy storage and its use with intermittent renewable energy," IEEE Trans. Energy Conversion, vol. 19, no. 2, pp. 441-448, June 2004.

[5] C. Abbey and G. Joos, "Super capacitor energy storage for wind energy applications," IEEE Trans. Industry Applications, vol. 43, no. 3, 769- 776, May/June 2007.

[6] B. S. Borowy and Z. M. Salameh, "Dynamic response of a stand-alone wind energy conversion system with battery energy storage to wind gust," IEEE Trans. Energy Conversion, vol. 12, no. 1, pp. 73-78, Mar. 1997.

[7] M.-S. Lu, C.-L. Chang, W.-J. Lee, and L. Wang, "Combining the wind power generation system with energy storage equipments," in Proc. IEEE IAS 43rd Annual Meeting, Edmonton, Canada, October 5-9, 2008.

[8] A. Yazdani, "Islanded operation of a doubly-fed induction generator (DFIG) wind-power system with integrated energy storage," in Proc. 2007 IEEE Canada Electrical Power Conference, Montreal, Quebec, Oct. 25-26, 2007, pp. 153-159.

BIBLIOGRAPHY:

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