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Interconnection Inverter Control System of PMSG Wind Power Generation

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Abstract

This paper presents the experimental results of the operation of the system interconnection inverter control side for wind power generation system (WPGS) using PMSG. The diode bridge rectifier converter methods are utilized as converters for the WPGS. The experimental results are obtained by the test bench using the wind turbine emulator. The wind turbine emulator are reproduced the behaviours of windmill by the servo motor drives. The servo motor is calculated from windmill wing profile, the wind velocity and windmill rotational speed. The WPGS using PMSG employs the vector control system to control the torque and speed of PMSG and the active power and reactive power are controlled and generated power is sent to the grid-connected power generation while controlling the DC link voltage in the inverter side.

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Keywords: Wind power generation, Inverter control system, Diode bridge rectifier converter

1. Introduction

At present, the practical application of wind generator systems using the PWM converter advances [1-3]. The cost is high because the PWM converter needs large number of switching devices and its control is complicated. However, the PWM converter is used for variable-speed large-capacity wind generator systems which require the control of windmill speed, because it can apply the vector control, and realizes the high-speed and high-precise generator

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torque control. As power generator system does not need to supply the excitation energy from the converter side, when the permanent magnet synchronous generator (PMSG) is used as a generator. Therefore, the wind generator systems using PMSG and the diode bridge rectifier converter for the purpose of charging battery are mainly driven at the rated wind velocity of which induced voltage becomes high enough [4].

The wind generator system using PMSG and diode bridge rectifier can constitute the low-cost converter. However, In the past the present study, we propose a diode bridge rectifier method as the system linkage system to be used in the wind power generation system, has conducted a performance evaluation by simulation [5]. In addition, it proposed a windmill emulator there is no need of wind tunnel facilities in order to carry out the actual verification. In this paper, we report that confirms the operation of the system interconnection inverter control side of the diode bridge rectifier converter method. The windmill rotational speed is controlled to maximize the efficiency of wind turbine against wind speed in low-and middle-range.

2. Wind Power Generation Systems

Fig. 1 shows the structure of wind power generation system using the diode bridge rectifier converter method. The proposed wind generator system is lower-cost than the conventional wind power system. However, the converter cannot control the generator torque. In short, the converter cannot control the wind turbine rotational frequency. Then, the inverter regulates the DC link voltage in order to control the generator torque.

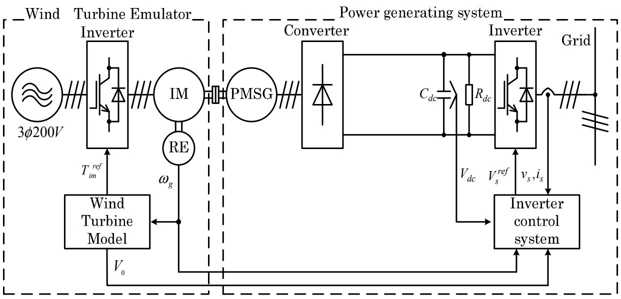


Fig.1. Structure of wind power generation system using diode bridge rectifier converter.

2.1. System interconnection inverter control

Fig. 2 shows the system interconnection inverter control for diode bridge rectifier converter method. The inverter control system maintains the DC link voltage. Also, this operating range corresponds to the ranges of wind velocity. In wind velocity under the rated wind velocity, the windmill speed control is carried out with the inverter control system. Concretely, the inverter control system adjusts the electric torque of PMSG by adjusting the DC link voltage, and it controls the windmill speed. and the inverter control system carries out the electric power control. The inverter control system is configured by the following equations of PI speed controller.

$$I_{sd}^{ref} = \left(K_{Pv} + \frac{K_{Iv}}{s} \right) \left\{ \left(V_{dc}^{ref} - V_{dc}^{ref\_w} \right) - V_{dc} \right\} \tag{1}$$

The DC link voltage is controlled by regulating the active current. The DC link voltage reference is calculated by subtracting outputs of PI speed and power controllers from constant DC link voltage reference by the following equations.

$$V_{dc}^{ref\_w} = \left(K_{ps} + \frac{K_{IS}}{s} \right) \left(\omega_g^{ref} - \omega_g \right) \tag{2}$$

The reactive current reference is constant of zero to keep the power factor at 1. The output voltage references are calculated by the following equations.

$$V_{sd}^{ref} = \left(K_{pd} + \frac{K_{Id}}{s}\right)\left(I_{sd}^{ref} - I_{sd}\right) + e_{sd} + \omega L I_{sd} \tag{3}$$

$$V_{sq}^{ref} = \left(K_{pq} + \frac{K_{Iq}}{s}\right)\left(I_{sq}^{ref} - I_{sq}\right) + \omega L I_{sq} \tag{4}$$

$$I_{sq}^{ref} = 0 \tag{5}$$

Fig. 3 shows the phase locked loop (PLL) control system. The PLL control system is provided in the library of MATLAB/Simulink.

The circuit consists the three-phase input signal is converted to a $dq0$ rotating frame using the angular speed of an internal oscillator.

The quadrature axis signal V_q is proportional to the phase difference between the grid system voltages of V_{su}, V_{sv}, and V_{sw} and the internal oscillator rotating frame.

The V_q is filtered with the variable frequency mean value block. The PID controller, with an optional automatic gain control, keeps the phase difference to 0 by acting on a controlled oscillator.

The PID output, corresponding to the angular velocity ω_s, is filtered and converted to the frequency f_s in hertz, which is used by the mean value.

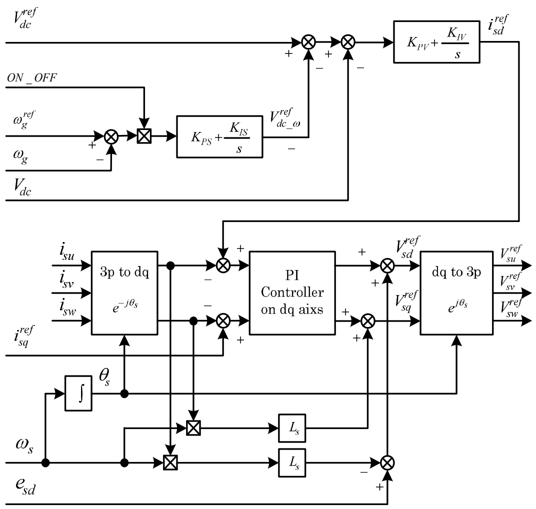


Fig.2. Inverter control system.

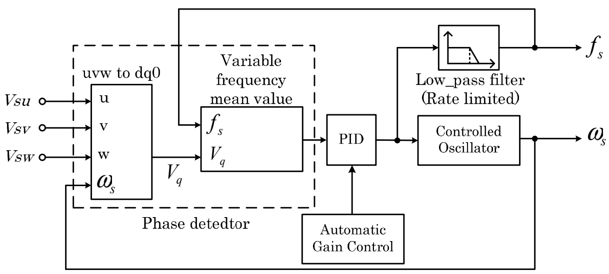


Fig.3. Phase locked loop control system.

3. Experimental Method

The system interconnection inverter control using the diode bridge rectifier converter method, active power is controlled to maintain the DC link voltage constant reactive power is controlled to maintain a power factor of 1 with respect to the mains voltage that. These control operation is performed in DSP, computed PWM signal, after being added the dead time via the FPGA board is input to the system interconnection inverter control.

The change in the output voltage of the generator is simulated by the battery voltage, and check the operation by observing the state of the DC link voltage. Figure 4 shows the experimental system.

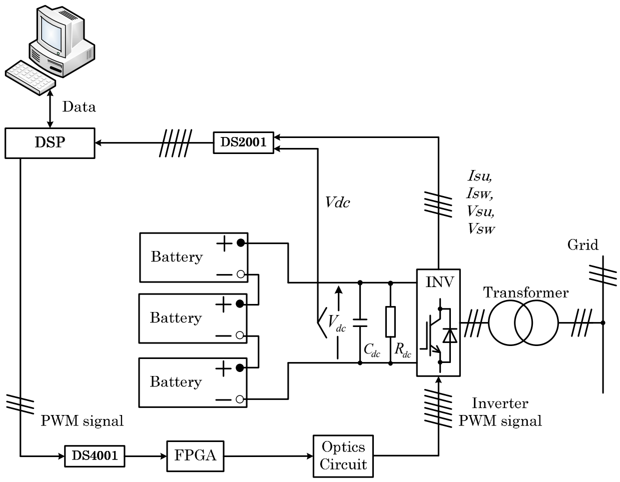


Fig.4. Experimental system of the system interconnection inverter control

Table I shows the control parameters. The control parameters of vector control system applied in the inverter sides are designed with the conventional method considering the arrangement of pole and zero.

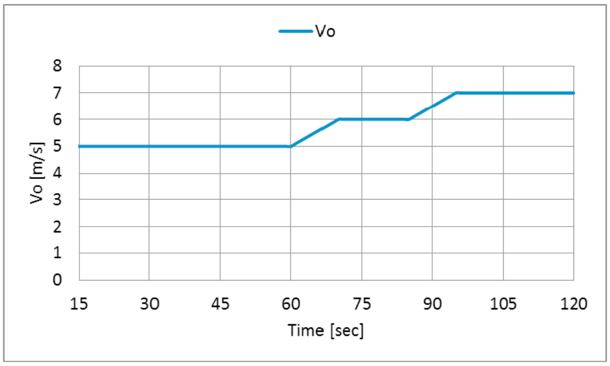
Table I. Control parameters of inverter side

Diode Bridge Rectifier Convertor Method	
Vector controller for Invertor	
Proportional gain of DC link voltage regurator	20
Integral gain of DC link voltage regurator	80
Proportional gain of speed regurator	0.1
Integral gain of speed regurator	2.5
Proportional gain of maxmum power regurator	0.000001
Integral gain of maxmum power regurator	0.001
Proportional gain of d axis current regurator	0.5081928
Integral gain of d axis current regurator	1448.34948
Proportional gain of q axis current regurator	0.5081928

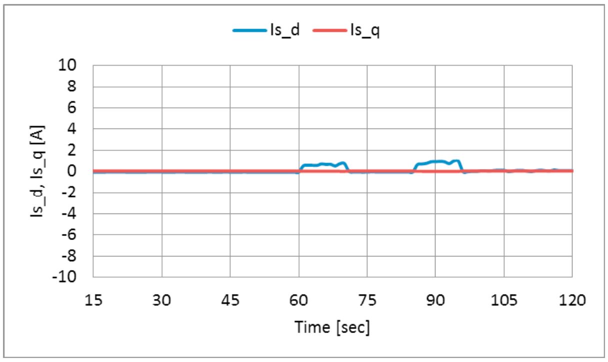
Integral gain of q axis current regurator	1448.34948
Setting of phase voltage	100/sqrt(3)
DC link voltage reference	50

4. Experimental Results

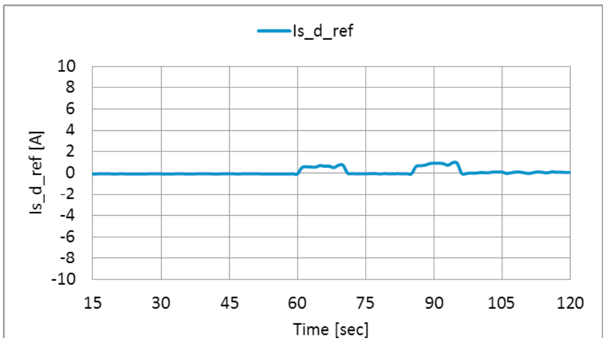
Fig. 5 Shows the experimental results of the interconnection inverter control system. the DC link voltage reference V_{dc}^{ref} to 50 [V], and the DC link voltage reference is calculated by subtracting outputs of PI speed controllers from constant DC link voltage reference $V_{dc\_w}^{ref}$ and the result when the battery voltage is 84 [V]. The DC link voltage was confirmed to have been controller.



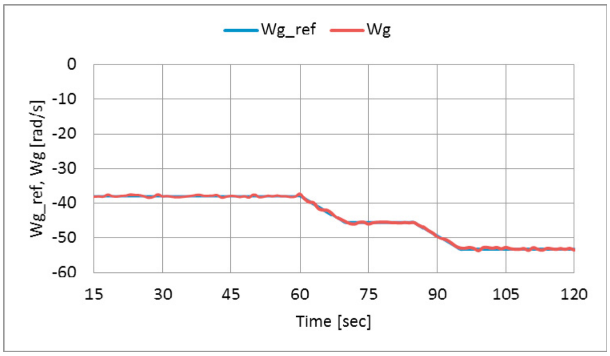
(a). Wind velocity



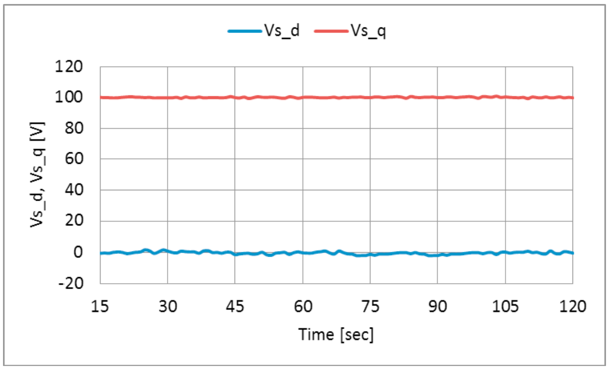
(b). d axis and q axis current of inverter side



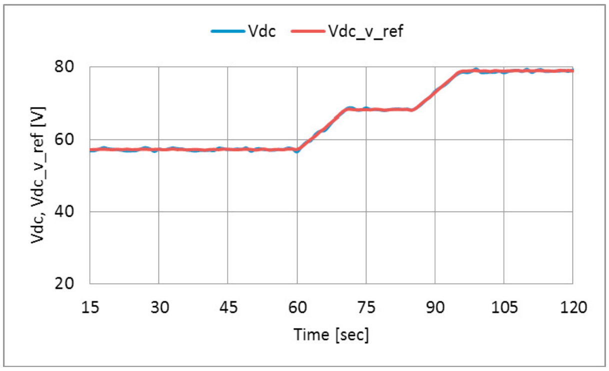
(c). d axis current reference of inverter side



(d). Rotational speed Reference and Rotational speed



(e). d axis and q axis voltage of inverter side



(f). DC link voltage and its reference

Fig.5 Experimental results of the system interconnection inverter control.

5 Conclusions

This paper described the control strategy of wind power generation system using diode bridge rectifier converter. The steady state and transient responses for wind velocity changes were tested by using the real machine. The simulation models of the variable-speed wind power generation system using the diode bridge rectifier converter are implemented by using MATLAB & Simulink. The experimental results of the wind power generation system using diode bridge rectifier converter. The fundamental performance of the wind power generation system using diode bridge rectifier converters were verified by discussing the experimental results.

References

1 Danilo Llano, Mark Tatlow and Richard McMahon : "Control algorithms for permanent magnet generators evaluated on a wind turbine emulator test-rig", Power Electronics, Machines and Drives (PEMD 2014), 7th IET International Conference on, pp.1-7 (2014)
2 Yanxia Shen,Juan Wu, Wenjing Zhou,Zhipu Zhao : "Fault-tolerant Strategy of Dual PWM Converter in Wind Power System", Cyber Technology in Automation, Control, and Intelligent Systems (CYBER 2015), IEEE International Conference on, 8-12 June 2015, pp. 808-813
3 Dong Jiang, and Fei (Fred) Wang :" Variable Switching Frequency PWM for Three-Phase Converters Based on Current Ripple Prediction", IEEE Transactions on Power Electronics, Volume:28, pp. 4951 – 4961(2013)
4 S. Tammaruckwattana, K. Ohyama, and C. Yue: "Experimental Assessment with Wind Turbine Emulator of Variable-Speed Wind Power Generation System using Boost Chopper Circuit of Permanent Magnet Synchronous Generator", Journal of Power Electronics, Vol. 15, No. 1, pp. 246-255, (2015)
5 Sirichai Tammaruckwattana, "Modeling and Simulation of Wind Power Generation System Using Diode Bridge Rectification Circuit for Converter", International Conference on Control, Automation and Systems (ICCAS 2015) in BEXCO, Busan, Korea, pp.132-137 (2015)