International Journal of Research (IJR)
e-ISSN: 2348-6848, p- ISSN: 2348-795X Volume 2, Issue 10, October 2015
Available at http://internationaljournalofresearch.org

Application of Excitation Synchronous Wind Power Generators with Maximum Power Tracking Scheme for distribution system

[1]Malyala Mahesh Babu & [2]M Ravi.

1.M.tech,KBR Engineering College,Pagidipally, Bibi Nagar, Hyderabad. pincode: 508126
2.Associateprofessor,KBR Engineering College,Pagidipally, Bibi Nagar, Hyderabad. pincode: 508126

Abstract:

This paper discusses the problem of maximum power point tracking (MPPT) of Wind Turbine based on a permanent magnet synchronous generator (PMSG) connected to power grid trough complete static converter. To achieve this, we propose a control scheme of synchronous generator, consisting of a DC/AC device followed by a second DC/AC device. The idea behind MPPT principle is turbine speed variation depending on wind speed in case of generator indirect connection to power grid. Simulations on Matlab-Simulink can be found at the end of the paper, confirming a good consistency with study objectives of control scheme, selection of setting parameters and complete converter architecture.

Introduction With soaring fuel prices and predictable exhaustion of fossil fuels, alternative options are increasingly considered. The beginning of the 21st century had been marked by a spectacular rush towards renewable energy conversion systems. The ultimate objective is to get away from dependence of conventional sources of energy. Recently, this trend increased, all the more, by considerations of ecological order. Indeed, the high consumption of the traditional fossil energy sources causes serious environmental damage. Thus, all countries are now called upon to contribute international effort to combat climate change. Among all the renewable energies, three main classes emerge: mechanical (sea swell, marine currents, wind, etc), electromagnetic (solar panels, etc) and thermal (geothermal, solar thermal, etc). In particular, wind power can be converted to mechanical power by water pumping or to electrical power by using appropriate generators. The latter form has expanded rapidly throughout the world, through both household and industrial applications in connection with power grid. In financial terms, the wind turbines have a low profitability [1], given the significant cost of installation. However, they have many advantages in terms of preserving non-renewable natural resources, limiting environmental pollution and operational autonomy. Theoretically, recovering power of wind turbine generators is limited to approximately 59% of the kinetic energy of the wind [1]. This is the Betz limit. The power coefficient Cp, takes into consideration this limit as well as frictional losses and varies with the rotational speed of the turbine. That is why, monitoring of the operating point at maximum power is recommended. Many studies have been carried out on approaches of MPPT [2]. Generally, MPPT methods can be broadly classified into those that not use sensors and those that use sensors. Sensorless methods [3] rely on the monitoring of the power variation. The others with sensors [3] are dedicated to researching the

MPPT by control of turbine torque and specific speed, commonly known by TSR (tip speed ratio) [4], [5]. TSR control regulates directly the turbine speed or torque to maintain the TSR at an optimum value by measuring the turbine speed. The adopted sensor method of MPPT requires real-time reading of wind speed as well as prior knowledge of wind turbine characteristics. It presents many advantages over HCS (hill climb search) method: fastness of convergence and greater stability of calculations at steady state [6]. The amount of energy recovered by conversion systems of wind energy (variable speed wind energy conversion system: VS-WECS), depends on the accuracy with which search of MPPT is done and also on the type of generator used. Energy conversion chains often use a permanent magnet synchronous generator [7]. This type of machine allows overcoming the problem of the excitation current supply, heavy to manage in a conventional synchronous machine. To maximize the efficiency of the wind generator, various solutions were examined at different levels of conversion chain [7] according to direct or indirect grid connection. Indirect grid connection of the generator provides, in addition to the advantage of optimizing the extracted power from the wind, the opportunity to save significant starting and synchronizing time before the connection to the power grid. The role of the power electronic interface, mounted between generator and grid, is to manage generator in order to extract the maximum of the power of the wind [8]. Ordinarily, conventional scheme of VS-WECS uses a controlled-rectifier. Indeed, Li et al [9] has proposed a control scheme of PMSG with PWM Controlled-rectifier. This device requires an important physical logistics (6 fully controllable switches). This study presents a complete scheme of wind turbine connected to power grid, using Permanent Magnet Synchronous Generator. The voltage generated by PMSG is rectified using a three-phase passive rectifier followed by a buck DC/DC converter. This device converts the AC voltage to DC voltage. The main circuit composition of grid side converter is a Boost DC/DC converter and a current Source Inverter followed by an isolation transformer. Power Components The control scheme of PMSG, which we propose (Fig. 1), is a complete convertor between PMSG and power grid with an intermediate storage capacitor. The generator side device is a cascade circuit including an uncontrolled three-phase bridge rectifier and a buck chopper [2]. Compared to MLI rectifier solution, this one gives the advantage of reliability, performance and low-cost material. However, the grid side device is a cascade circuit including a boost chopper and a current source inverter (CSI) followed by an isolation transformer This means an instantaneous energy recovery enabling a battery saving with all that this implies in terms of environmental impact and maintenance management.

CONTROL PRINCIPLES OF PROPOSED WIND POWER GENERATOR SYSTEM

Depicts the control framework of the proposed system. The control system design concepts maintain power flow balance between the input and the output and, simultaneously, force the generator frequency to synchronize with the utility grid. When the system complies with these conditions, the generator output can be connected to the utility grid network, subsequently reaching the high efficiency and maximum power tracking objectives. The control signals, including the generator voltage, current, grid phase, motor encoder, and output power, are sensed and transferred to the microprocessor control unit

(MCU). The servo motor controller plays an important role in output power and grid voltage phase tracking. A situation in which the controller detects a power increase from the servo motor implies decreasing wind speeds. At this moment, the system regulates the exciter current to reduce the excitation generator output power. A chain reaction subsequently occurs in which the servo motor power returns to a balanced level. During the energy balance periods, the servo motor consumes only a slight amount of energy to stabilize the shaft speed. Once (1) is satisfied, both the maximum power and the constant speed can be obtained by the designed control scheme.. The wind turbine provides mechanical torque to rotate the generator shaft via the speed-increasing gear box. As the generator shaft speeds reach the rated speed, the generator magnetic field is excited. The MPTC then controls the output voltage reaching grid voltage. Moreover, the generator output waveform is designed in phase with the grid using the servo motor control track grid sine waveform. Owing to the difficulty in precisely estimating the wind speed, the proposed MPTC scheme measures the motor output power as the reference signals to determine the generator output power. The excitation synchronous generator output frequency, voltage-phase, and output power are fed back into the control scheme. The phase/frequency synchronization strategy

MAXIMUM POWER TRACKING CONTROL

In a natural environment, the wind power varies with time. To stabilize the generator output voltage, current, and output power, the excitation synchronous generator output power has to track the input power variation and react immediately by adjusting the excitation field current. In this paper, a maximum power tracking control scheme is proposed. The proposed MPTC scheme includes two control loops which is motor power control loop, and the generator power control loop. By MPTC scheme, it can make the motor consumption power minimize and most of wind power can be transferred to the grid by the generator If an air dynamic occurs in the wind turbine, the servo motor responses to this change for maintaining generator speed constant.

The three-phase servo motor power is calculated and compared to the servo motor command . In this state, the servo motor command is set equal to zero. The servo motor deviation signal command passes by the motor power control loop to obtain the signal. As is expected, in the steady state, the servo motor consumes less power

THREE-PHASE EXCITATION SYNCHRONOUS GENERATOR MODEL

For a typical three phases, four poles excitation synchronous generator, the generator output power is governed by the excitation controller, through the slip rings, with the appropriate excitation current sent to the armature winding. Based on the rotating magnetic field affection, the stator windings induce three-phase alternate voltages which have frequency in synchronization with the rotor speed According to the conductor’s electromagnetism and the mechanical forces on the stator winding and rotor, the generator back electromotive force voltage

CONCLUSION

This paper presented an excitation synchronous wind power generator with MPTC scheme. In the proposed framework, the servo motor provides controllable power to regulate the rotor speed and voltage phase under wind disturbance. Using a phase tracking control strategy, the proposed system can achieve smaller voltage phase deviations in the excitation synchronous generator. In addition, the maximum output power tracking scheme governs the input and output powers to achieve high performance. The excitation synchronous generator and control function models were designed from the physical perspective to examine the presented functions in the proposed framework. Experimental results demonstrate that the proposed wind power generator system achieves high performance power generation with salient power quality.

REFERENCES

[1] M. Liserre, R. Cárdenas, M. Molinas, and J. Rodriguez, "Overview of Multi-MW wind turbines and wind parks," IEEE Trans. Ind. Electron., vol. 58, no. 4, pp. 1081–1095, Apr. 2011.

[2] V. Delli Colli, F. Marignetti, and C. Attaianese, "Analytical and multiphysics approach to the optimal design of a 10-MW DFIG for direct-drive wind turbines," IEEE Trans. Ind. Electron., vol. 59, no. 7, pp. 2791–2799, Jul. 2012.

[3] B. Singh and S. Sharma, "Design and implementation of four-leg voltagesource-converter-based VFC for autonomous wind energy conversion system," IEEE Trans. Ind. Electron., vol. 59, no. 12, pp. 4694–4703, Dec. 2012.

[4] A. Di Gerlando, G. Foglia, M. F. Iacchetti, and R. Perini, "Axial flux pm machines with concentrated armature windings: Design analysis and test validation of wind energy generators," IEEE Trans. Ind. Electron., vol. 58, no. 9, pp. 3795–3805, Sep. 2011.

[5] S. Zhang, K.-J. Tseng, D. M. Vilathgamuwa, T. D. Nguyen, and X.-Y. Wang, "Design of a robust grid interface system for PMSG-based wind turbine generators," IEEE Trans. Ind. Electron., vol. 58, no. 1, pp. 316–328, Jan. 2011.

[6] F. Bu, W. Huang, Y. Hu, and K. Shi, "An excitation-capacitor-optimized dual stator-winding induction generator with the static excitation controller for wind power application," IEEE Trans. Energy Convers., vol. 26, no. 1, pp. 122–131, Mar. 2011.

[7] S. Le-peng, T. De-dong, W. Debiao, and L. Hui "Simulation for strategy of maximal wind energy capture of doubly fed induction generators," in Proc. IEEE Int. Conf. Cognit. Informat., Jul. 2010, pp. 869–873.

[8] W. Qi, C. Xiao-hu, F. Wan-min, and J. Yan-chao, "Study of brushless doubly-fed control for VSCF wind power generation system connected to grid," in Proc. Int. Conf. Electr. Utility Deregulation Restruct. Power Technol., Apr. 2008, pp. 2453–2458.

[9] A. Mesemanolis, C. Mademlis, and I. Kioskeridis, "Maximum efficiency of a wind energy conversion system with a PM synchronous generator," in Proc. IEEE Int. Conf. Exhib. Power Gener. Transm. Distrib. Energy Convers., Ayia Napa, Cyprus, Nov. 2010, pp. 1–9.

[10] H. Geng, D. Xu, B. Wu, and G. Yang, "Active damping for PMSG-based WECS with DC-link current estimation," IEEE Trans. Ind. Electron., vol. 58, no. 4, pp. 1110–1119, Apr. 2011