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A Review on Excitation Synchronous Wind Power Generators with Maximum Power Tracking Scheme

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Abstract: The global electrical energy consumption is rising and there is a steady increase of the demand on the power capacity, efficient production, distribution and utilization of energy. a novel excitation synchronous wind power generator (ESWPG) with a maximum power tracking scheme. The excitation synchronous generator and servo motor rotor speed tracks the grid frequency and phase using the proposed coaxial configuration and phase tracking technologies. The generator output can thus be directly connected to the grid network without an additional power converter. Maximum wind power extraction for a wind energy conversion system composed of a wind turbine, a squirrel-cage induction generator, and a matrix converter (MC). a small wind generation system where neural network principles are applied for wind speed estimation and robust maximum wind power extraction control against potential drift of wind turbine power coefficient curve. The new control system will deliver maximum electric power to a customer with lightweight, high efficiency, and high reliability without mechanical sensors. A turbine directly driven permanent magnet synchronous generator (PMSG). Power electronic, the technology of efficiently processing electric power, plays an essential part in the integration of the dispersed generation units for good efficiency and high performance of the power systems.

Keywords: Excitation synchronous generator, maximum power tracking, servo motor control, wind power.

I. INTRODUCTION

This Power electronic, being the technology of efficiently converting electric power, plays an important role in the field of modern electrical engineering, it is an essential part for the integration of dispersed generation unit to achieve high efficiency and performance in power systems. The use of permanent-magnet synchronous machines (PMSMs) for wind power generation. The PMSMs can provide high-efficiency and high-reliability power generation, since there is no need for external excitation and no copper losses in the rotor circuits. In addition, the high-power-density PMSMs are small in size, which reduces the cost and weight of wind turbines. The wind generation system equipped with a PMSM and power-electronic converters, the wind turbine can be operated to extract the maximum power from the wind at various wind speeds by adjusting the shaft speed optimally. Therefore, the PMSMs are commonly used for small variable-speed wind turbines to produce high-efficiency, high-reliability, and low-cost wind power generation. A Variable-Speed wind-turbine configuration including an induction generator and a matrix converter (MC). The system consists of a wind turbine, a gearbox, a squirrel-cage induction generator (SCIG), and an MC, A wind power generator in grid connection applications, except for doubly fed induction generators, achieves these features using variable speed constant frequency technology. However, most excitation synchronous wind generators cannot be connected directly to the grid, owing to instabilities in wind power dynamics and unpredictable properties that influence the generator synchronous speed. The direct drive permanent magnet synchronous wind generator (PMSWG) uses variable speed and power converter technologies to fulfill the grid connection requirements, which has advantages of being gearless. a novel converter less wind power generator with a control framework that consists of an excitation synchronous generator, permanent magnet (PM) synchronous servo motor, signal sensors, and servo control system. The wind and servo motor powers are integrated with each other and transmitted to the excitation synchronous generator via a coaxial configuration.

When the wind speed varies, the servo motor provides a compensatory energy to maintain constant generator speed. The additional servo motor power is also transformed into electricity, and output into the load. This means that the motor power is not wasted. Using a precise phase tracking function design, the proposed robust integral servo motor control scheme reduces the output voltage phase shift in the excitation synchronous generator from wind excitation field current to ensure that the excitation Synchronous generator fully absorbs the wind power, and converts it into electricity for the loads. Based on physical theorems, a mathematical model for the proposed system is established to evaluate how the control function performs in the designed framework.

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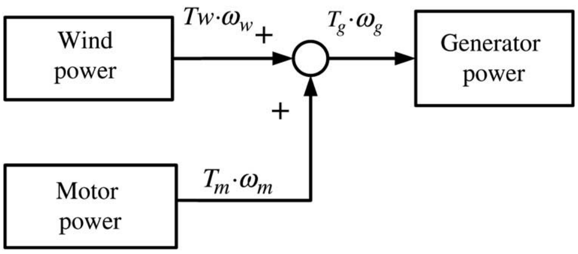

Fig.1. Power flow block diagram.

Disturbances, According to the servo motor power magnitude and the generator power, the proposed maximum power tracking scheme controls the excitation field current to ensure that the excitation synchronous generator fully absorbs the wind power. The wind generator rotor shaft input-end receives rotating torques from the speed increasing gear box. The tail-end of the generator rotor shaft is coupled with a servo motor. The input energy of the excitation synchronous generator is the sum of the wind power and servo motor powers. The speed and rotating direction for the wind turbine output, servo motor, and excitation synchronous generator is the same, i.e., the system speeds satisfy. This arrangement can reduce the power transmission losses. The wind generator rotor shaft input-end receives rotating torques from the speed increasing gear box. The tail-end of the generator rotor shaft is coupled with a servo motor. The input energy of the excitation synchronous generator is the sum of the wind power and servo motor powers. The speed and rotating direction for the wind turbine output, servo motor, and excitation synchronous generator is the same, i.e., the system speeds satisfy. This arrangement can reduce the power transmission losses.

II. LITERATURE SURVEY

Tzuen-Lih Chern et. al [1] "Excitation Synchronous Wind Power Generators With Maximum Power Tracking Scheme" 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.

Frede Blaabjerg et. al [2]"Power Electronics as Efficient Interface in Dispersed Power Generation Systems" More and more dispersed generation units are being integrated into power systems. The difference in the characteristics between the dispersed generation units and the load/system demand requires a conditioning system. Power electronic converters play a vital role in the integration. In this paper, the developments of modern power electronics have been discussed. The applications of power electronics in various dispersed generation units, in particular wind turbine generation systems and offshore wind farms, fuel cells and PV generators have been reviewed and it is clear that power electronics is the enabling technology for dispersed power generation.

S. Masoud Barakati et. al [3]"Maximum Power Tracking Control for a Wind Turbine System Including a Matrix Converter". An MPPT method for the wind turbine system including an MC is presented in this paper. The controller equipped with the MPPT algorithm controls the shaft speed to maximize the power captured from the wind. This is possible by adjusting the MC output frequency according to the constant V/f strategy. The controller also adjusts the MC variables to control the reactive power transfer at the grid interface to regulate the power factor. Two MPPT methods, P&O and PSF, are explained. The P&O method is suitable only for low-inertia wind turbine systems, and the PSF method relies on the measurement of shaft speed. An improved power signal feedback method, called mechanical speed-sensor less PSF, is proposed for the wind turbine system under study that neither requires a wind velocity sensor nor a shaft speed sensor. Simulation results show successful tracking of maximum power at varying wind velocities.

Eftichios Koutroulis et. al [4] "Design of a Maximum Power Tracking System for Wind-Energy Conversion Applications". In this paper, the development of a novel WG maximum power tracking control system is presented, comprising of a high-efficiency buck-type dc/dc converter and a microcontroller-based control unit. The advantages of the proposed MPPT method are as follows: 1) no knowledge of the WG optimal power characteristic or measurement of the wind speed is required and 2) the WG operates at variable speed and thus suffering lower stress on the shafts and gears compared to constant-speed systems. The proposed MPPT method does not depend on the WG wind and rotor-speed ratings nor the dc/dc converter power rating. Experimental results of the proposed system indicate that the WG output power is increased by 11%–50%, compared to the case where the WG is directly connected via a rectifier to the battery bank. The proposed method results in a better exploitation of the available wind energy, especially in the low wind-speed range of 2.5–4.5 m/s, where the power production of the battery-rectifier configuration is relatively low. The proposed method can be easily extended to include battery charging management or additional RES control, while it can also be modified to control a dc/ac converter in the case of a grid-connected wind-energy-conversion system.

Wei Qiao et. al [5] "Control of IPM Synchronous Generator for Maximum Wind Power Generation". Considering Magnetic Saturation PMSGs are commonly used for small variable-speed WTG systems. In such systems, by adjusting the shaft speed optimally, the maximum wind power can be extracted at various wind speeds within the operating range. In addition, when using an IPMSG, the stator copper and core losses of the generator can be minimized by optimally controlling the d-axis component of the stator currents.

However, to achieve the high performance of the WTG system, magnetic saturation of the IPMSG must be taken into account in the control-system design. This paper has proposed an output-power-maximization control scheme for an IPMSG in a variable-speed wind-power generation system. The proposed control scheme can extract the maximum wind power from the wind at various wind speeds below the rated value while minimizing the stator copper and core losses in the IPMSG simultaneously.

The effect of magnetic a duration, which causes the highly nonlinear characteristics of the IPMSG, has been considered in the control-scheme design. The IOL technique is applied to design the high-performance nonlinear current controllers in order to eliminate the effects of nonlinearity caused by magnetic saturation. Implementation results have shown that the proposed control provides the wind generation system with high dynamic performance and improved power efficiency.

III. METHOD

Power electronic for wind power Generation systems Characteristics of Wind Power Conversion The aerodynamic power of a wind turbine is given by

$$p = \frac{1}{2}\rho\pi R^2 \upsilon^3 C_p \qquad (1)$$

where ρ is the air density, R is the turbine radius, is the wind speed, and C_P is the turbine power coefficient which represents the power conversion efficiency of a wind turbine. C_P is a function of the tip speed ratio (λ), as well as the blade pitch angle (β) in a pitch controlled wind turbine. λ is defined as the ratio of the tip speed of the turbine blades to wind speed, and given by

$$\lambda = \frac{R \cdot \Omega}{\upsilon} \qquad (2)$$

Where Ω is the rotational speed of the wind turbine. A typical CP –λ curve for a fixed pitch angle β is shown in Fig. 2. It can be seen that there is a maximum power coefficient, C_{Pmax}.

Normally, a variable speed wind turbine follows the C_{Pmax} to capture the maximum power up to the rated speed by varying the rotor speed to keep the system at λ_{opt}. Then it operates at the rated power with power regulation during the periods of high wind by the active control of the blade pitch angle or the passive regulation based on aerodynamic stall. A typical power- wind speed curve with a cut-off wind speed of 25 m/s is shown in Fig.3; however, the cut-off wind speed may vary depending on the type of wind turbines.

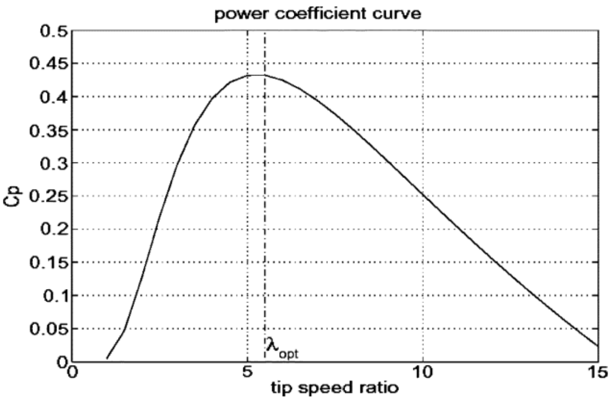

Fig. 2 Typical Cp - λ curve for a wind turbine.

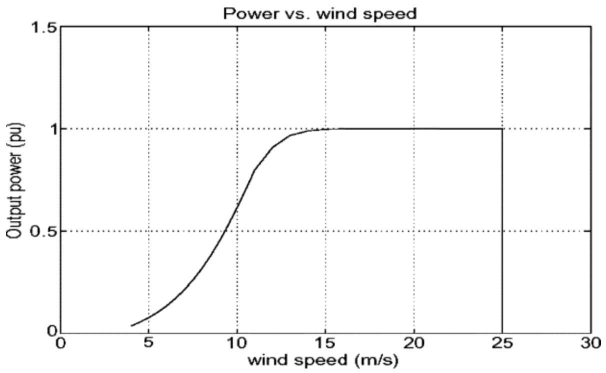

Fig. 3 Power-wind speed characteristics for a wind turbine.

IV. CONCLUSION

In this 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. PMSGs are commonly used for small variable-speed WTG systems. In such systems, by adjusting the shaft speed optimally, the maximum wind power can be extracted at various wind speeds within the operating range. a neural network based control is presented for both small wind turbine directly driven permanent magnet synchronous generator system and cage induction machine wind generation system with gearbox. The applications of power electronics in various dispersed generation units, in particular wind turbine generation systems and offshore wind farms, fuel cells and PV generators have been reviewed and it is clear that power electronics is the enabling technology for dispersed power generation.

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