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An Optimal Wind Power Generation of Variable Speed AC Generator by Using MPPT and Fuzzy Logic Controller

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Abstract: In today's unending search for sources of alternative energy, clean, green and renewable energies are given top priorities using wind power to generate electricity is a perfect fit. Wind power is the conversion of wind energy into electricity. This is achieved by using wind turbines, which convert the kinetic energy into electric energy. To obtain the maximum output tracking control procedure is used. A Wind generator (WG) maximum power point tracking (MPPT) system is presented consisting of normal H-bridge converter, inverter and a high efficiency boost type DC/DC converter, three phase inverter and a fuzzy logic based control unit running the MPPT function. The advantages of proposed MPPT method are no knowledge of the optimal power characteristics or measurement of the wind speed is required and the wind generator operates at variable speed. Thus, the system features high reliability, lower complexity and cost and the less mechanical stress of the WG.
Keywords: Wind Generator (WG), DC-DC Converter, Maximum Power Point Tracking (MPPT), Power Electronic Converter (PEC), Permanent Magnet Wind Generator (PMWG).

1. Introduction

The variable-speed wind generators are designed to operate at an optimal speed rotation as a function of the wind speed. The Power Electronic Converter (PEC) may control the generator rotation speed to get the highest possible power by way of a Maximum Power Point Tracking (MPPT) algorithm. It is also possible to avoid exceeding the supposed power if the wind pressure speed increases by means of power control mechanism of wind generator. Wind Generators (WG`s) have been widely used both in self-governing systems for power supply isolated loads and in grid-connected applications. Although WGs have a low installation cost compared to photo voltaic, the overall system cost can be more reduced using greatest efficiency power converters, controlled such that the optimal power is acquired according to the current full of atmosphere conditions. The WG power production can be instinctively controlled by changing the rotor blade pitch angle [1]. On the other hand WG`s of special construction are required, which is not the regular case, especially in small size stand-alone Wind Generator systems.

In this paper it is based on the WG optimal power versus the rotating torque-speed characteristic, which is usually stored in a Microcontroller memory. The WG rotate speed is calculated then the optimal output power is calculated and compare to the actual WG power output. The resultant fault is used to control a power interface. In a same version found in [5], the WG output power is calculated and the intend rotor speed for best possible power generation is derived from the WG optimal power versus rotor-speed characteristics. The target rotor speed is compared to the actual speed, and the error is used to control a DC/DC power converter. The control algorithm has been implementing in Lab VIEW running on a pc. In Permanent-Magnet Wind Generator (PMWG) system, the output current and rotor speed, respectively. In [6] and [7], the rotor speed and voltage are proportional to the Electromagnetic torque calculated and the actual current is used to control a DC/DC characteristics. The fault resulting from the measurement of the converter is calculated according to the measured WG output voltage of the current versus the rotational-speed optimal while the optimal output current and calculated by using an approximation method. The difficulty of all above method is based on the knowledge of the WG optimal power characteristics which is typically not available with a high degree of accuracy and also changes with rotor ageing. Another approach using at two layers Neural Network (NN) [8] inform online and the preprogrammed Wind Generator power characteristic by perturbation of the control signals in the order of the values provided by the power characteristic. However, under real operating condition wherever the wind speed changes quickly, the continuous neural network guidance required results in precision and control-speed reduction of the wind generator.

2. Maximum Power Point Tracking

The maximum extractable power depends not only on the strength of the source (i.e. wind pressure) but also on the operating point of the WECS. The model of MPPT is to optimize the generator speed relation to the wind velocity intercept by the wind turbine such that the power is maximum Variable-speed wind generators are planned to operate at an optimal rotation speed as a function of the wind speed. The electronic converter may control the turbine rotation speed to get the maximum possible power by means of a MPPT Algorithm.

3. Torque Input of Wind Turbine

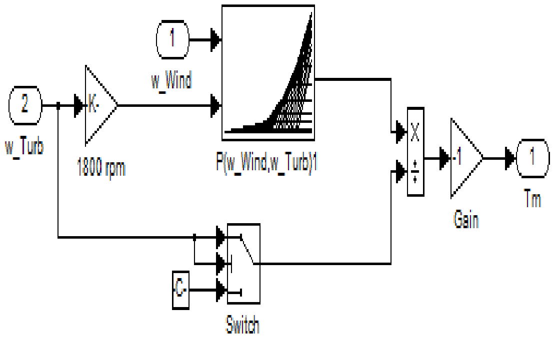

Figure 1: Simulation diagram of Torque input of Wind mill

the proposed system is illustrated in Fig.1. The MPPT algorithm is based on observe the WG output power using measurement of the WG output voltage and current and directly adjusting the DC/DC converter duty cycle according to the result of assessment between succeeding WG outputs of the power values.

4. Overall Simulink Diagram

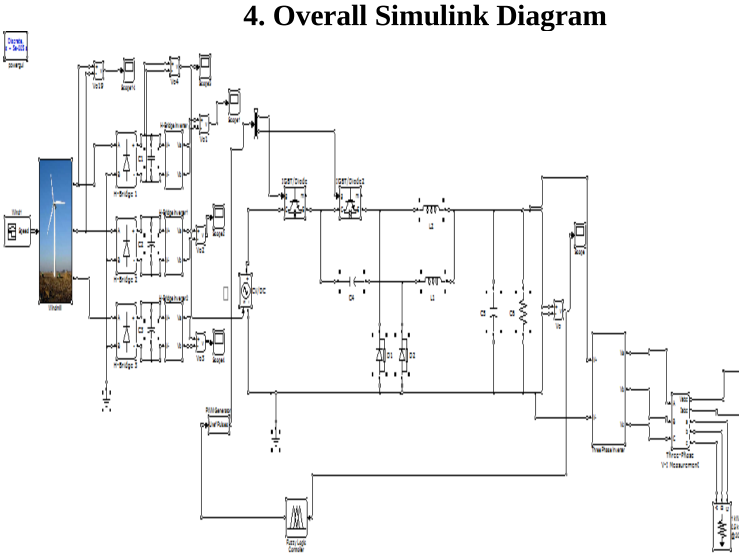

Figure 2: Simulation diagram of overall system

5. Input Variable Speed

Implementations of Fuzzy Logic based control systems transfer the maximum power from a Wind-Energy Conversion system to the utility grid or to a stand-alone system have been presented in [9] and [10], respectively. The controllers are based on a polynomial approximation of the optimal power versus the wind-speed characteristics of the WG. In this paper, an alternative approach for Wind generator maximum power point tracking (MPPT) control is described.

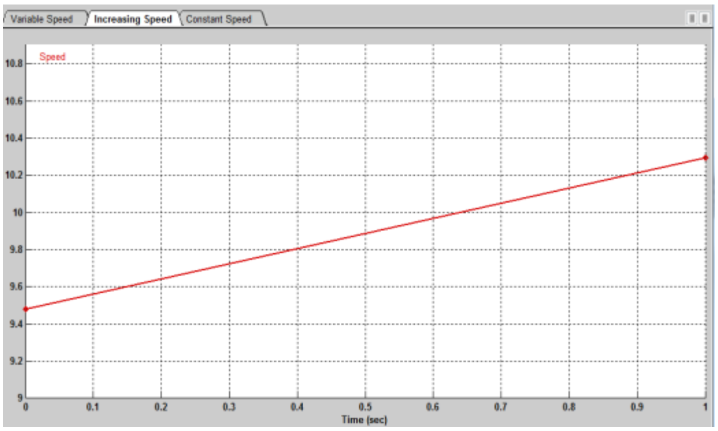

Figure 3: Variable speed Input

6. Closed Loop of Wind Turbine

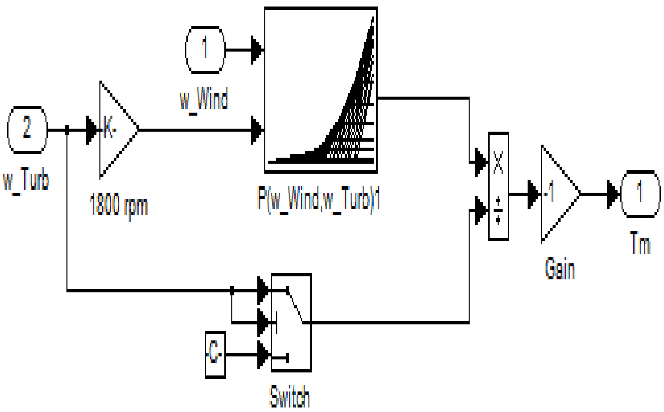

Figure 4: Simulation diagram of Wind Turbine

The Simulation diagram of Torque input of Wind mill diagram of the proposed system is illustrated in Fig.4. The MPPT algorithm is based on observe the WG output power using measurement of the WG output voltage and current and directly adjusting the DC/DC converter duty cycle according to the result of comparison between successive WG outputs of the power values.

7. Normal Wind Output

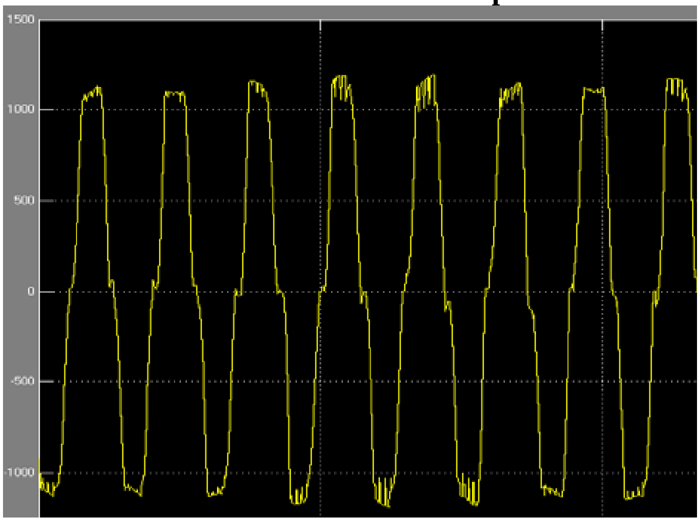

Figure 5: Wind Output

8. Normal Converter Output

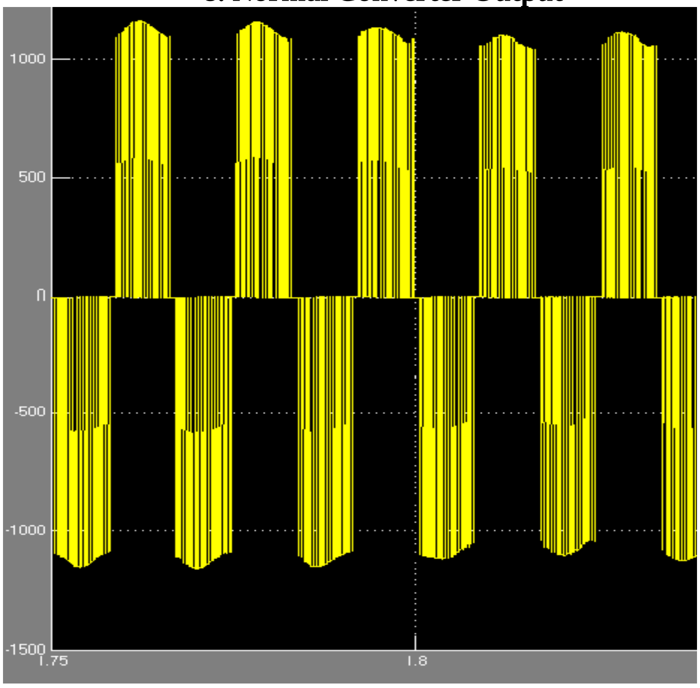

Figure 6: Converter Output

9. DC Converter

The standard unidirectional topology of the DC-DC boost converter also known as step-up converter or chopper, it consist of a switching-mode power device containing mostly two semiconductor switches (a rectifier diode and a power transistor with its consequent anti-parallel diode) and two energy storage space devices (an inductor and a smooth capacitor) for produce an output DC voltage at a level larger than its input DC voltage [8]. This converter act as an interface between the full-wave rectifier bridge and the VSI, by employ pulse-width modulation (PWM) control techniques.

10. Fuzzy Logic Output

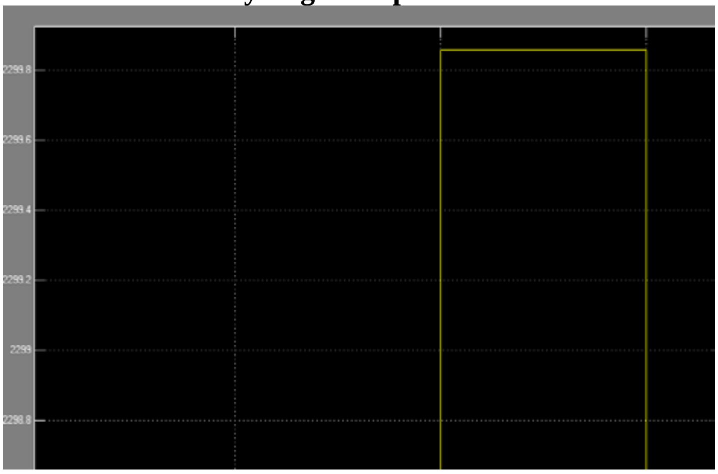

Figure 7: Fuzzy Logic Output

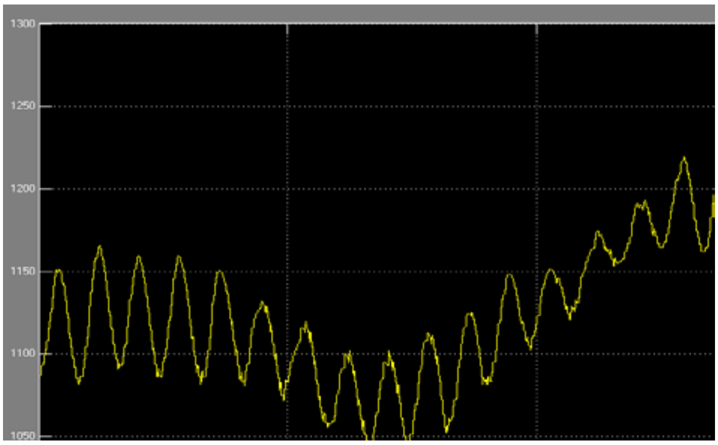

Figure 8: Fuzzy Logic Output

9. Conclusion

In this paper, the development of a novel Wind Generator maximum power tracking control system is presented, include of a high-efficiency buck-type DC/DC converter and a Microcontroller-base control unit. The return of the proposed MPPT method are as follows: 1) no information of the WG optimal power feature or measurement of the wind speed is necessary and 2) the WG operate at variable speed and thus suffering lower stress on the shaft and gear compared to constant-speed systems. The planned MPPT method does not depend on the WG wind and rotor-speed ratings or the DC/DC converter power ranking.

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Author Profile

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Appendix: Overall Simulation diagram of Wind mill