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Fuzzy Logic control strategy for tracking the maximum power point of a horizontal axis wind turbine

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Abstract

Wind energy is affected by the stochastic nature of the wind speed, the purpose of this labor is to improve the machine's production efficacy. This control strategy estimates the restoring torque of generator adjusting the generator speed ratio, in this paper we will apply a fuzzy logic strategy to maximize the power by optimizing parameter adjusting on system, we consider in input of controller the wind speed and generator acceleration. Simulation results are given and discussed with MATLAB/SIMULINK to validate the proposed control strategy. This control strategy has a good performance in terms of dynamic response and steady property.

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Keywords: Wind turbine; ewind nergy; Fuzzy logic; wind speed; generator speed; maximum power; control strategy.

1. Introduction

Wind energy is one of the important renewable energy sources. As opposed to the currently existing carbon-based energy sources such as coal, petroleum, and natural gas, wind energy has clean, unpolluted, inexhaustible, and free advantages in term of its natural existence.

Most works done in this field, aim to improve the efficiency of power production of wind turbine by optimizing structures and introducing more intelligent algorithms than conventional methods; A Several control methods of

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wind energy conversion system had been proposed by researchers to maximize the wind energy production [5,6,7,8], the most of proposed methods have low efficiency to extract the power, Therefore, the extracted energy is the very unstable since the stochastic nature of wind flow unstable since the stochastic nature of wind flow.

Wind turbines are becoming more reliant on advanced control systems to maximize the energy captured from the wind and also to minimize the loads of these machines. The development and the use of control systems to improve performance require accurate models of the wind turbine environment and also turbine response [2, 9].

This paper aims to apply a maximum power point tracking (MPPT) algorithm that is based on fuzzy logic prediction into a wind turbine with variable speed generator model. In general, the wind turbines power efficiencies are limited by the natural aerodynamic limits named betz limit. Hence, the MPPT control strategies are expected to improve and to increase the power efficiency to the maximum level within the limited boundary. In this paper, the wind turbine is modeled as a horizontal-axis wind turbine (HAWT) because it has the higher power coefficient, while the generator will be a variable speed synchronous generator due to the speed variation feature and the higher optimal rotor speed [10].

This paper is organized as follows, the wind turbine model used for control is described in the second section, in the third part the fuzzy logic control strategy is presented and applied on the system, finally the results obtained by MATLAB simulation is done, it show the efficiency and the robustness of the proposed method of MPPT and its good performances compared with the classical.

Nomenclature

Cp	power coefficient
$Cp_{\max}$	maximum power coefficient
P_a	aerodynamic power
P_v	wind power
T_a	wind torque
λ	speed ratio
β	pitch angle
λ_{opt}	optimal speed ratio
β_{opt}	Rotor speed ratio
R	rotor radius
T_s	low speed shaft torque
ω_g	generator speed
ω_r	rotor speed
ng	gearbox ratio
K_s	shaft stiffness
B_S	shaft damping
B_g	generator damping
B_r	rotor damping
T_{em}	electromagnetic torque
J_r	rotor inertia
J_g	generator inertia
V_{wind}	Wind speed
U	the crisp output
$u_a(Z)$	the aggregated output membership function
$Kd\omega$	gain of rotor acceleration
KV_{wind}	gain of wind speed
Ku	gain of generator torque
FLC	fuzzy logic control
MPPT	maximum power point tracking
TSR	tip speed ratio
NB	negative big