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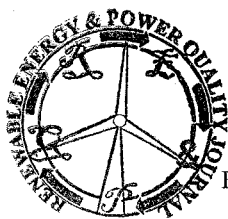
Research and Design of Fixed-Pitch Non-Grid-Connected Wind Power System

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Abstract. Traditional fixed-pitch wind turbine, whose rotational speed is a constant, adjusts its aerodynamic power according to the blade stall characteristic, and it has the advantage of being simple, robust and reliable, with simple and inexpensive electric systems. By introducing MPPT strategy on low wind condition and constant output power control on high wind condition, higher efficiency of fixed-pitch wind turbine can be obtained, which is realized by regulating the turbine rotational speed according to wind speed. In this paper, the variable speed regulation strategy is proposed, the stability characteristic based on the small signal model is analyzed, and the speed control technique based on disturbance observer and Internal Model PID controller is discussed in detail, some experimental results are presented, which show that the dynamic response of speed controller is favorable and efficiency of the plant is improved by tracking the maximum power point on low wind condition and keeping the turbine aerodynamic power at its rated value on high wind condition.

Key words

Wind power, Fixed-Pitch, Aerodynamic Power Regulation, Disturbance Observer, Internal Model PID

1. Introduction

Wind energy is a pollution-free renewable energy, which received wide attention from more and more countries around the world, and wind power plays an important part in solving the energy crisis. The total capacity of all wind turbines installed worldwide reached 175 Giga-watt in mid-2010, compared with 159 Giga-watt by the end of 2009^[1]. The world market for wind turbines saw robust growth.

The rotational speed of variable speed wind turbines can be adjusted according to the change of wind speed, which allows the turbine to operate with the optimum power efficiency and highly improves the working efficiency of wind turbines. According to different wind turbine aerodynamic power regulation methods, there are two

basic plant types, the fixed-pitch type and the variable-pitch type. The latter one is equipped with both rotational speed and turbine blade control systems, which enable it the best power characteristic and it has been widely used in medium and large-scaled wind farms nowadays. But for small-scaled ones, e.g. the non-grid-connected wind power system, it increases the whole costs by implying the complicated parts. Differs from pitch-controlled types, fixed-pitch variable speed wind turbine adjusts its aerodynamic power by fully control the shaft speed and it can achieve the comparable power characteristic in theory. Besides that, it takes the advantage of being simple, reliable, and much cheaper, which makes it very suitable for medium and small-scaled wind farms.

This paper focuses on the design of generator-side converter control based on active-rectify topology fixed-pitch variable speed wind power system, and the aim is to achieve the optimal control with energy efficiency criterion. The steady state and dynamic characteristics of the turbine are being researched, which show that the plant is unstable under indirect speed control strategy on high wind condition, so direct speed control strategy is introduced. Vector control is applied to PMSG, so the design method of speed controller is given, and the instability of the system is eliminated by applying the disturbance observer and Internal Model PID technique. HIL experiments are done at last, which show that the fixed-pitch variable speed wind turbine can be operated stably in all operating wind speed and the speed controller have good dynamic characteristics.

2. Variable Speed Control Strategy Design

A. Fixed-Pitch Wind Turbine Model

Ignore the complex aerodynamic equations, fixed-pitch wind turbine model is determined by the following equations^[2]