中文摘要

在現行的小型風力發電系統中，大多採用由二極體整流器與直流轉換器所組成的二級式交直流轉換器。其主要缺點為在發電機側將會產生嚴重的電流諧波失真，其不僅會降低效率亦會對風力機造成額外的機械應力進而產生擾人的機械噪音。此外，在現有的最大功率控制法中，最佳轉矩控制法廣泛應用於小型風力發電系統中。但其只考量到系統於穩態下之情況，並未考慮於風速變化下之系統動態特性。因此，在風速快速變化時，由於機械轉動慣量所造成的緩慢動態響應便會減少風力機的發電量。為了克服上述的缺點且在兼顧發電效能與成本考量下，本論文提出一新型無感測式最大功率追蹤控制器及一高效率單級式交直流轉換器。主要的貢獻可摘要如下：

首先提出一新型無感測式動態最佳轉矩最大功率追蹤控制器，其中利用所提的虛擬慣量調整法來改善風力機的動態響應進而增加其發電量。接著為改善電力品質及轉換效率，本論文提出一高效率單級式交直流轉換器來取代習用的二級式交直流轉換器。如此不僅可將發電機電流的總諧波失真大大的降低至約 5%以下，同時也減小了風力機的機械應力與擾人的噪音。隨後本論文更提出一半同步整流技術來進一步降低由背接二極體所造成的導通損。另外，為了更進一步降低於不連續導通控制法下開關的切換損失，本論文遂將連續導通控制、不連續導通控制及半同步整流技術整合為一整合式控制法。本論文並實際建構一測試平台用以驗證所提理論之可行性與效能。最後，由實測結果可知本論文所提之系統整體效率能有效提升 12%至 15%，回收年限則能縮短 11%至 13%。

關鍵詞：小型風力發電系統、最大功率追蹤、可調式虛擬慣量、半同步整流

ABSTRACT

A well-known two-stage ac to dc converter composed of a diode bridge rectifier and a dc converter is widely used in the existing small wind power generation system (WPGS). However, due to the nonlinearity of the diode bridge rectifier, there will be significant total harmonics distortion (THD) in the generator currents which will not only reduce the efficiency but also result in additional mechanical stress and undesired acoustic noise. As to the maximum power point tracking (MPPT) controller, the widely adopted optimal torque control algorithm only concerns about the steady state characteristics of the wind turbine. However, the poor dynamic response due to the mechanical inertia effect will result in reduction of the wind turbine efficiency under rapidly changing wind speed situations. To overcome the above disadvantages, a novel sensorless dynamic MPPT controller and a high efficiency single-stage ac to dc converter are proposed in this dissertation as a compromise of both performance and cost for a small WPGS.

Basically, the major contributions of this dissertation can be briefly outlined as follows. First, a novel sensorless dynamic optimal torque MPPT control with adjustable virtual inertia technique is proposed to improve the wind turbine dynamic response and increase the output power. In addition, since the proposed novel MPPT control contains no mechanical sensors, both the reliability and cost performance index can be further improved. Second, a single-stage converter with three active switches is proposed to replace the conventional two-stage converter for improving the power quality and efficiency. The generator current THD is greatly reduced to around 5% which can reduce the corresponding mechanical stress and acoustic noise as well. Third, a novel quasi-synchronous rectification technique is proposed to further reduce the conduction losses of the body diodes. Moreover, a hybrid control composed of partial CCM, partial DCM and QSR techniques is proposed for the corresponding single-stage converter to reduce the losses. From the experimental results, one can see that the total efficiency of the whole system can be increased by 12% to 15% and the payback period is reduced by 11% to 13% approximately.

Keywords: small-scale wind power generation system, maximum power point tracking, adjustable virtual inertia, quasi-synchronous rectification