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Direct Driven Axial Flux Permanent Magnet Generator for Small-Scale Wind Power Applications

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Abstract. Small-scale wind power applications require a cost effective and mechanically simple generator in order to be a reliable energy source. The use of direct driven generators, instead of geared machines, reduces the number of drive components, which offers the opportunity to reduce costs and increases system reliability and efficiency. For such applications, characterized by low speed of rotation, the axial flux permanent magnet generator is particularly suited, since it can be designed with a large pole number and high torque density.
This paper presents an axial flux permanent magnet synchronous generator, double sided with internal rotor and slotted stators. Such a structure gives a good compromise between performance characteristics and feasibility of construction. The design process of the machine is described and validated by test experiments.

Key words

Wind energy, axial flux, permanent magnet generator, direct driven, design.

1. Introduction

There is currently significant interest in the development of small-scale wind turbines for the urban environment, with both horizontal and vertical axis being considered [1-3]. Small-scale wind turbines are also an attractive choice for autonomous applications and for rural areas where the installation of a distribution grid is not economically reasonable [4].

The power range of those systems is usually about 500 W to 5 kW. Permanent magnet excitation is favoured in this power range, from the point of view that the required volume of permanent magnets is nowadays costly affordable. The main advantages of permanent magnet synchronous generators over wound-rotor generators are due to the fact the first ones do not require any external excitation current, which translates in a significant decrease in rotor losses and also allows the use of a diode bridge rectifier at the generator terminals, with significant cost benefits in the power converter topology [5-7].

Permanent magnet excitation also allows a significant decrease of the pole pitch, which translates in cost and mass reduction [8]. This assumption together with the axial flux generator configuration favour the use of a direct driven generator (gearless system) because it allows the use of higher pole number [9]. Furthermore, axial flux permanent magnet machines are recognized for having higher torque density than their counterparts based on radial-flux, this being more apparent in a design with a large number of poles.

Axial flux permanent magnet machines may be designed in various configurations [10-12]. A double-sided axial flux permanent magnet synchronous generator with internal rotor intended for small-scale wind energy systems was proposed on [13]. In this paper, the analytical design of the machine is enhanced with finite element analysis (FEA). Experimental test results are carried out.

2. Generator concept

Axial flux machines are characterized by an axially directed airgap flux. The simplest structure uses one stator ring form and a disk rotor (Fig. 1), both having the same active inner and outer diameters which defines the active part of the machine where the electromechanical conversion takes place.