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A new axial flux permanent magnet synchronous alternator autonomously adapted to wind speeds

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ABSTRACT

In this study, a new axial flux permanent magnet synchronous generator (PMSA) design and prototyping procedures are presented. It is composed of a stack of rotor–stator blocks on the same shaft. In other words, it is made up of four alternators based on axial flux permanent magnets that can generate electrical energy within the limits of rotor rotational speed with varying wind speeds. A control system is also introduced to the generator. The control system connects or disconnects the stator blocks to the load according to the changing speeds of the wind. It produces electrical energy with stable voltage, frequency and variable power at the output. The efficiency of the generator is tested with different load and speed conditions. It is observed that the efficiency is high when the speed is low in case the load is connected only one stator. The efficiency is high when the speed is above 200 rpm for the case where several stators are connected to the load. It can be seen that the incremental structure of the generator is suitable for changing speeds of the wind. It can have high efficiency for both low and high speeds with changing the number of stator blocks connected to the load.

1. Introduction

In this study, a new axial flux permanent magnet synchronous generator (PMSA) design and prototyping procedures are presented. It is composed of a stack of rotor–stator blocks on the same shaft. In other words, it is made up of four alternators based on axial flux permanent magnets that can generate electrical energy within the limits of rotor rotational speed with varying wind speeds. The main problem in producing electrical energy from the wind is that the wind speed is changing frequently. This in turn brings difficulties in obtaining a constant power, voltage and frequency at the output of the generator. Normally, a gear box follows the generator to regulate them even though the wind speed changes. Since the gear box is a mechanical device, it gives rise to loss of a lot of power and reduces the efficiency of the generator. In addition, the gear box is bulky equipment and increases the volume and weight of the generator system. The main aim of our study is to eliminate the gear box from the generator

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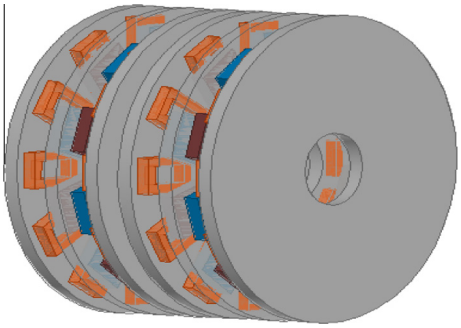

Fig. 1. Slotted alternator structure developed in this study.

system and increase the efficiency of the generator together with reducing the volume and the weight of the overall system. We replace the gear box with an electronic unit. We introduce a new approach to regulate the power, voltage and the frequency of the output by means of electronic control of alternator blocks autonomously. Our approach is such that each of the synchronous alternators consists of a rotor with permanent magnets on it and a stator with windings. All the rotors of the alternators are mounted on the same shaft. Hence, all the rotors rotate with the same speed and induce voltages across the coils of the stators. The voltage of the first alternator is selected as the reference voltage. When this voltage reaches the target value, this alternator output is connected to the load. When the reference voltage decreases below the desired level, it is removed from the load. Based on the increase (decrease) in the reference voltage, second, third and fourth alternators are connected (disconnected) to the load. Hence, a block of alternators are obtained that can operate with varying wind speeds. This structure can give an opportunity to be operated with varying wind speeds without any gear boxes and big losses in power and can produce energy with high efficiency compared to traditional wind turbines. Unlike the traditional high power systems, it is possible to produce electric energy for the wind speeds of 2–3 m/s by means of our system. For

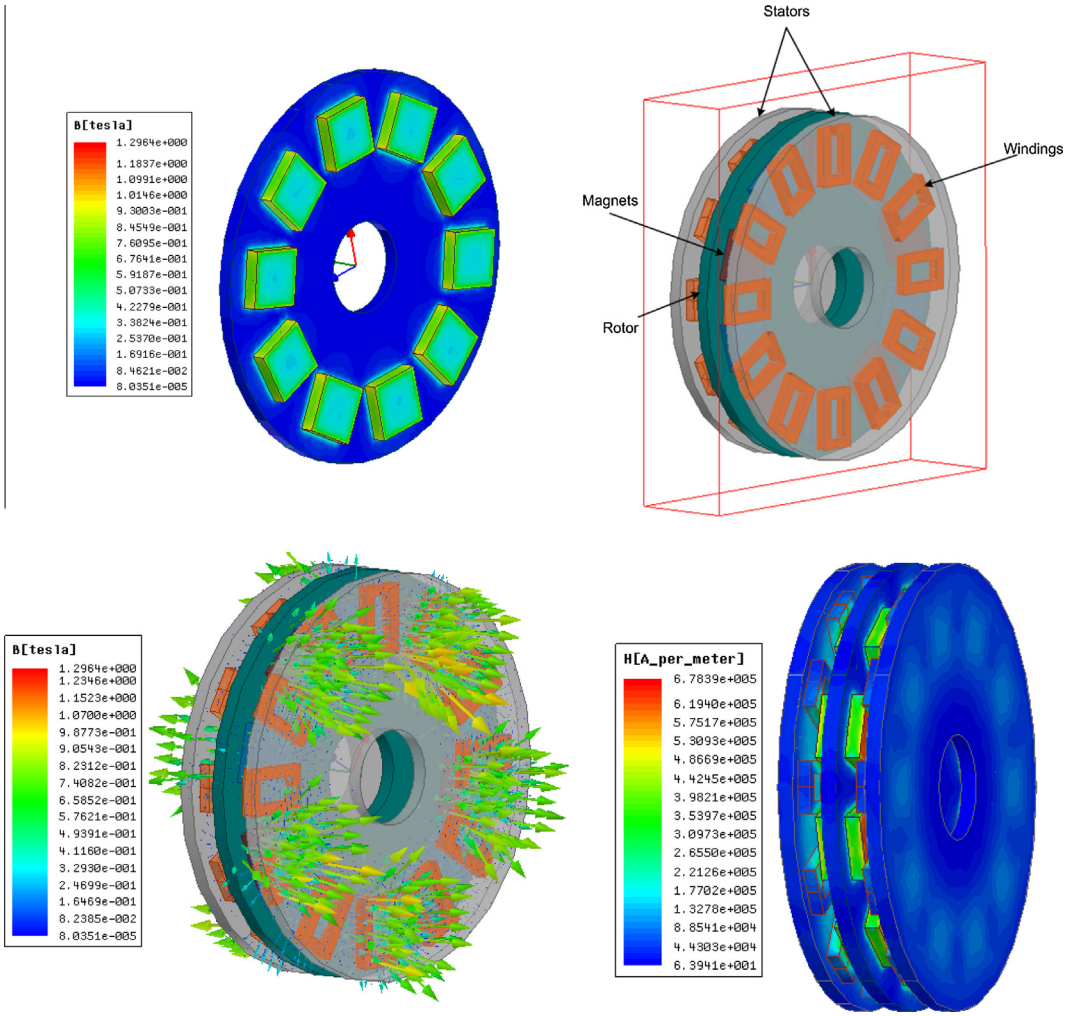

Fig. 2. The behavior of the magnetic flux of the permanent magnets by use of the Ansys–Maxwell simulation software.