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New Controllable Field Current Induced Excitation Synchronous Generator

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Abstract

The electrical machine using induced excitation system is a kind of brushless self-excited machine with low cost and high reliability, the induced excited machine would provide high power density at high-speed. But the low efficiency of the excitation system limits the development of this kind machine. Based on traditional excitation system, an improved construction induced excitation system is proposed in this paper. Adaptive control method is used to control the current direction in the stator auxiliary winding to replace constant DC excitation, the input current can change its direction according to the position of the rotor, the result is that all of induced currents at work in excitation system. Position sensors are fixed on the rotor and the stator field winding currents can synchronize with the rotor position according to the signal of the sensors. Experiments with the proposed structure are performed and compared with those of the traditional induced excitation system one. The results show that the new structure can improve the excitation system efficiency and reduce the cost.

Keywords: *synchronous generator, induced excitation system, brushless and exciterless, new full-wave, controllable field current*

1. Introduction

Small synchronous generators are wildly uesd in shipping illumination, the urban power supply and family electrical equipments, which need to have the performance such as self-exiting, constant-voltage, good dynamic performance, compendious structure, stable operation, reliable quality, convenience in control and maintenance. There are two kind of synchronous generator excitation systems: semiconductor electromagnetic structure and permanent magnet structure. The structure of the semiconductor electromagnetic excitied synchronous generator is complex in comparison with that of the permanent magnet machine.It is difficult to adjust the output voltage of the permanent magnet excitied synchronous generator. Thus the induced excitation synchronous generator is designed in recent years,which would achieve a good balance between cost, reliability, power density, and high-speed capability.

In this paper, several induced excitation systems are studied. Based on these existed structure, an improved construction induced excitation system is provided and adaptive control method is used in this new excitaiton system. Experiments are proposed to validate the structure. Compared to those of the traditional induced excitation system, the new structure can improve the excitation system efficiency and reduce the cost.

2. Induced Excitation System

The induced excitation synchronous generator, which does not need any exciter or brushes to provide its DC field current, it has an induced current to supply its field current. it consists of an auxiliary winding on the stator which is additional to the main stator winding, a diode rectifier circuit on the rotor from which the DC field currents are supplied by rectification of the induced currents in the rotor auxiliary field. The field current can be adjusted by changing the input of the stator auxiliary winding.

The induced excitation method can be traced back to the 1960's, Researchers from Kyushu University in Fukuoka, Japan adopt the exciterless and brushless excitation system in a single-phase salient pole synchronous generator and improved the power factor. Its features

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included a diode rectifier circuit on the rotor, the diode rectifier circuit and the exciting windings serially connected so as to form a closed circuit, as shown in Figure 1 [1-3].

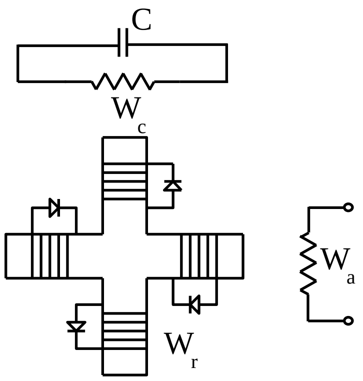

Figure 1. Single-phase Salient Pole Induced Excitation Synchronous Generator

Since then researchers in Japan developed the double-pole exciterless and brushless excitation system in a single-phase salient pole synchronous generator. its stator is composed of main winding w_a which outputs power and auxiliary winding w_e which add the exciting current, and the number of main poles is double as the auxiliary winding, as shown in Figure 2 [4, 5].

Because of the induced excitation synchronous generator with single-phase and salient pole system, the aberration of voltage and current wave become severe, the three-phase induced excitation synchronous generators should be of great significant, This can be schematically seen in Figure 3 [6, 7].

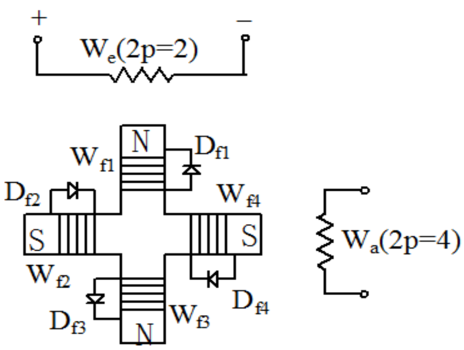

Figure 2. Single-phase Double-pole Induced Excitation Synchronous Generator

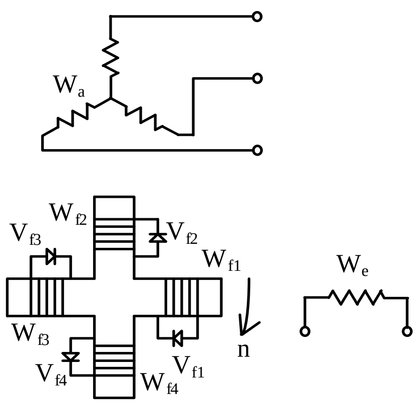

Figure 3. Three Phase Induced Excitation Synchronous Generator

However there has an obstacle problem in the study of the induced excitation synchronous generator, The internal excitation system adopts half-wave commutation mode, the DC field current is supplied by rectification of the induced currents in the rotor, which significantly reduces the efficiency to half of the original, it is a great impediment to its development and application in practical application.

Researchers at the Shandong University have been working in this area for a long time, in order to improve the induced excitation system's efficiency, researchers proposed a new configuration of double-pole induced excitation with mixed connected rotor winding, the transfer coefficient of the new configuration can be improved, but its value was limited, This can be schematically seen in Figure 4 [8-11].

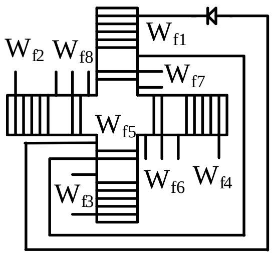

Figure 4. New Configuration of Double-pole Induced Excitation with Mixed Connected Rotor Winding

3. The Proposed Method

This paper proposes a new approach to increase excitation system efficiency. Based on the principles mentioned above, a diode rectifier circuit on the rotor is changed into short circuit, all the diodes are removed. The input current of the stator auxiliary winding is no longer purely constant DC, the direction of current will be changed according to the position of the rotor. The induced currents in the rotor will be changed from alternating current to pulse DC. The results show that all of the induced currents are active in excitation system, we call this a new full-wave induced excitation system, as shown in Figure 5.

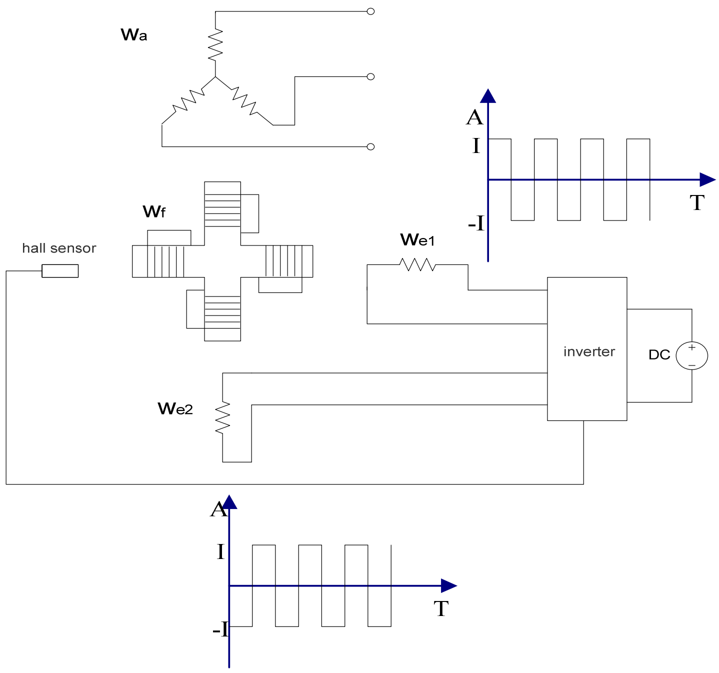

Figure 5. New Full-wave Induced Excitation Synchronous Generator

This paper puts forward a method of motor hall sensor on-line monitor to detect the the position of the rotor, and the inverter drive signals are synchronized with the position sensor output signals so that synchronism between the stator field winding currents and the rotor position is ensured for any speed.

4. Results and Discussion

A low-power test prototype of the new structure is produced. The expriments are performed and the test results of the expriments can well validate the theoretical analysis.

The rated parameters include:P_N=3kW,U_N=400V,f_N=50Hz,n_N=1500rpm,the rotor winding N_f=300, the stator field winding N_e=270.

The experimental results, shown in Figure 6, indicate that the rotor current in the old induced excitation system is half-wave, another half-wave was lost.

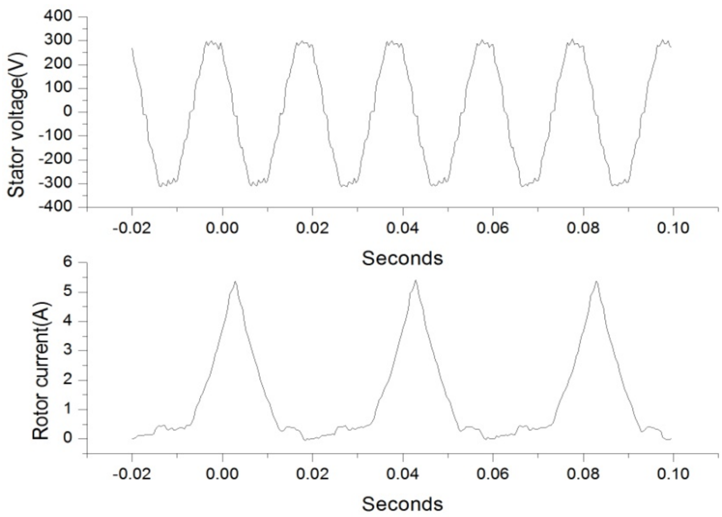

Figure 6. The Rotor Current Waveform and Stator Voltage Waveform

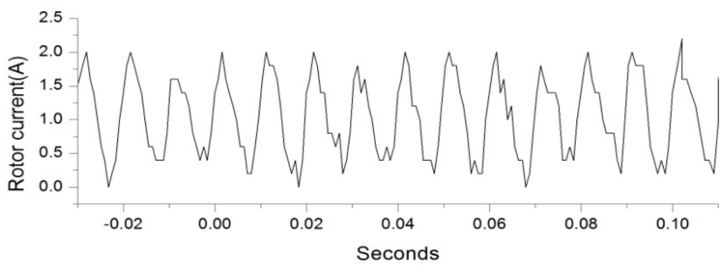

Figure 7. The Rotor Current Waveform of the Full-wave Induced Excitation

The experimental results by the new method of full-wave induced excitation are shown in Figure 7. By comparison of the test results of the two prototypes, it is shown that the rotor current is the full wave.

5. Conclusion

This paper presents a new structure of induced excitation system. By testing the performance parameters of experimental prototype, its performance index can meet the technical and performance requirement. The results showed that the proposed new full-wave induced excitation generator can improve the efficiency and reduce the cost.

Acknowledgements

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