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Simulation and Experiment of Power Generation System of Cage Asynchronous Motor

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Abstract: In order to verify the performance of the proposed control method, simulation experiments are carried out in the case of sudden change of load power and speed. The simulation results show that the new control method can speed up the output DC voltage stability speed, reduce overshoot, and restore stability of torque and flux faster than the traditional voltage outer-current inner-loop control method which is of great significance to anti-impact load capability in the wide speed range. Finally, experiments are carried out under variable speed and sudden load reduction using the experimental platform environment. The experimental results show that the Super-Twisting sliding mode control method can improve the dynamic characteristics of the system and verify the validity of the theory.

1. Introduction

With the development of high-power microwave weapons, laser weapons, electromagnetic guns and other advanced weapons and information technology, the power demand of self-contained equipment loading weapon system (radar, artillery, missile, etc.) has greatly increased, such as a large number of high-tech equipment on the tank (such as the electric drive device of high-power artillery aimed at in the process of moving, high-power laser guidance device, high-power The traditional vehicle power system needs to add diesel engine and generator to the vehicle to supply power to the electrical equipment. The traditional power supply mode has many problems, such as large space, low power density, lack of flexibility, inconvenience and high cost, which can not meet the new combat conditions For the requirements of lightweight, high efficiency and maneuverability of weapon system, the new vehicle mounted power generation system uses the power of vehicle engine to reduce the cost of the system and improve the flexibility of the system.

The cage type asynchronous motor has simple structure, no brush slip ring, can adapt to the harsh conditions in the field environment, and has high reliability. It is commonly used in motor occasions, and is widely used in various speed regulating traction systems. In power generation occasions, it is mainly used in small-scale water power generation, small-scale off grid wind power generation and other independent power generation occasions. In the above scenarios, the speed

range of the generator is limited, so the voltage and frequency of the generator can be stabilized in a certain range by using capacitor excitation and some auxiliary adjustment measures. This method of connecting a set of capacitors with appropriate capacity at the stator end to obtain the excitation current is called self excitation. This kind of asynchronous motor, which operates as an independent power source, can not get the reactive power provided by the grid when generating electricity. Therefore, the terminal voltage of self excitation asynchronous motor is difficult to maintain stability, so additional compensation equipment is needed to provide reactive compensation for the motor, which leads to self excitation the limitation of stepper motor in power generation state is that the speed and load of prime mover vary greatly in vehicle, airborne and other occasions. In this case, in order to ensure the stability of output voltage amplitude of generator, it is necessary to adjust the capacity of excitation capacitance continuously, and it is impossible to adjust the reactive power continuously. Obviously, the power quality produced by this power generation system is better Poor control. Therefore, in order to obtain stable power supply and reduce the volume and weight of vehicle power supply, the vehicle power take-off power generation system based on power electronics technology came into being. This independent power supply system no longer requires the trailer to load additional diesel generators and generators for power generation, but uses the vehicle's own engine for power generation, thus greatly reducing the volume and weight of the vehicle, however, it is necessary for the vehicle to have a large capacity of driving engine. At the same time, due to the constant changes of the battlefield environment and road conditions, the engine speed of the vehicle changes constantly. If appropriate compensation means are not adopted, the frequency and amplitude of the three-phase output voltage of the power supply will change constantly, and the quality of the power supply of the vehicle power system will be greatly reduced. With the continuous increase of information equipment, more and more modern electronic equipment in the vehicle electrical equipment become, these equipment have higher requirements for power quality, therefore, the vehicle power system of power take-off generation must achieve stable power output through a series of compensation measures, such as using advanced control strategy, changing converter topology and other methods.

2. Simulation Research of induction motor power generation system

The scheme of cage induction motor self-excited power generation system is relatively novel, and its feasibility needs to be verified by simulation and experiment. The voltage stabilizing control strategy proposed in this paper also needs to carry out simulation and Experimental Research on the system.

The simulation and experimental research of cage type induction motor self-excited power generation system mainly includes the following aspects: the steady-state performance research, the dynamic performance research, the voltage building process of DC bus voltage and the characteristics research of the system with load.

The main parameters of the system are as follows: DC bus side voltage; generator rated line voltage; generator rated power; IPM module switching frequency; DC bus capacitance; AC side filter inductance; self excitation capacitance; generator rated speed.

At home and abroad, the research of asynchronous motor power generation system has been more in-depth, but it is mainly used in wind power and hydropower, and it is not widely used in vehicle power supply, so it is necessary to simulate the asynchronous motor power generation system of vehicle power supply.

This paper mainly studies the dynamic and static performance of the generator system when the speed and load of the motor change.

The internal structure of the self-excited generation system of asynchronous motor is shown in

the figure below:

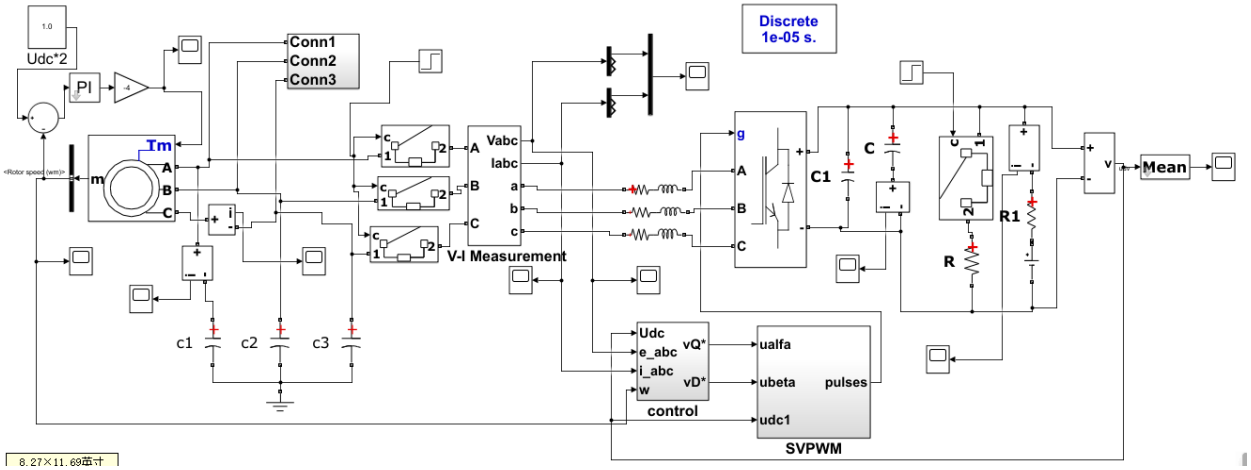

Figure 1. Internal structure diagram of self-excited electric system of asynchronous motor

The internal structure of DC load network is shown in the figure below:

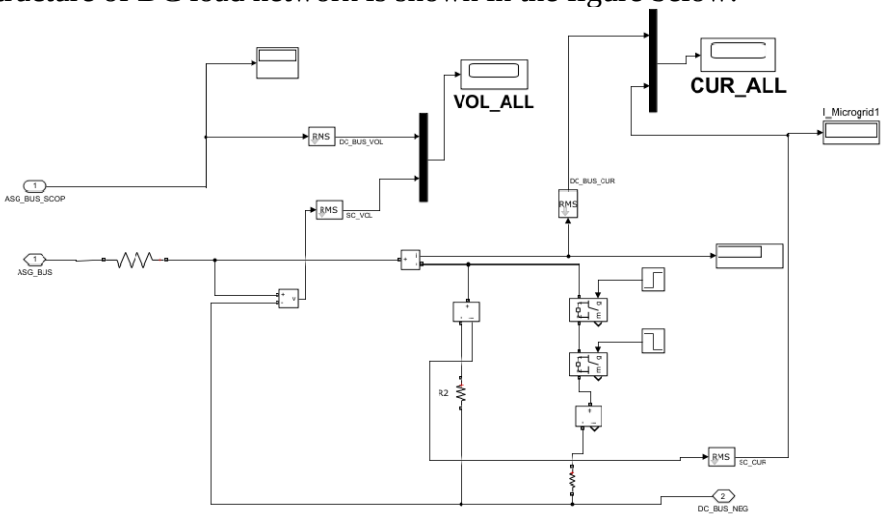

Figure 2. Internal Structure Diagram of Load Network

The simulation condition is that the rated power of the motor is 50KW, the rated voltage is 380V, the pole pairs are 2, the rotor range is 600-2500r / min, the unit value of the stator resistance is $R_s = 0.01216$, the unit value of the stator reactance is $L_{ls} = 0.0244$, the unit value of the rotor resistance is $R_r = 0.0152$, the unit value of the rotor reactance is $L_{lr} = 0.0241$, and the rotor moment of inertia $H = 0.04s$. The AC side filter inductor $L = 2mH$, DC side filter capacitor $C = 2200\mu F$, switching frequency of PWM rectifier 15KHz, DC side output voltage $U_{dc} = 700V$

3. Simulation Research of induction motor power generation system

3.1 Voltage loop regulation with conventional PI regulation

Firstly, carry out the simulation experiment of constant speed and sudden load change. The

simulation condition is that when the speed is 1500r / min, the load suddenly adds 33kw at 0.25s, and when the speed is 1.05s, the load suddenly unloads to simulate the impact load disturbance. The simulation results of using the conventional PI regulation method of voltage outer loop current inner loop are shown in Figure 3.

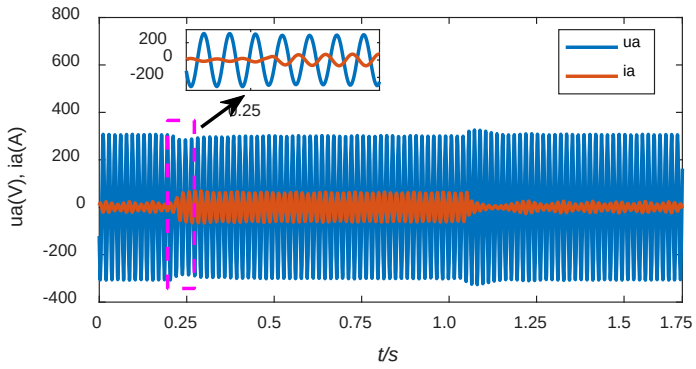

Figure 3. PI Regulating Curve of Traditional Voltage Outer Loop-Current Inner Loop under Load Change

Secondly, carry out the simulation experiment of constant load and speed change. The simulation condition is that the speed changes from 1000r / min to 1800r / min in 0.25s. The simulation results are shown in the following figure.

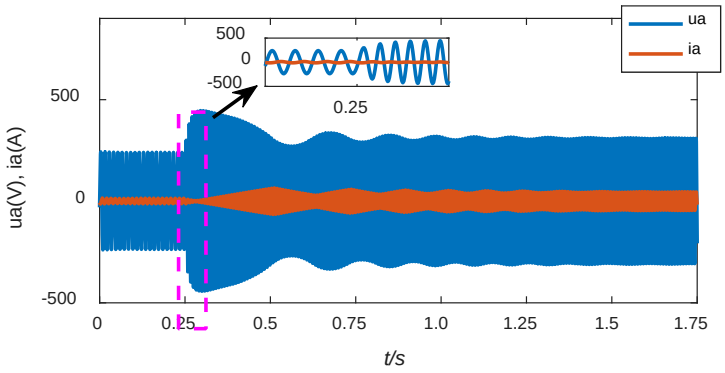

Figure 4. PI Regulating Curve of Traditional Voltage Outer Loop-Current Inner Loop with Variable Speed

3.2 Using super twisting sliding mode control to adjust the outer loop of voltage flux linkage

First, carry out the simulation experiment of constant speed and load change. The simulation conditions are the same as before, and the simulation waveform is shown in the figure below.

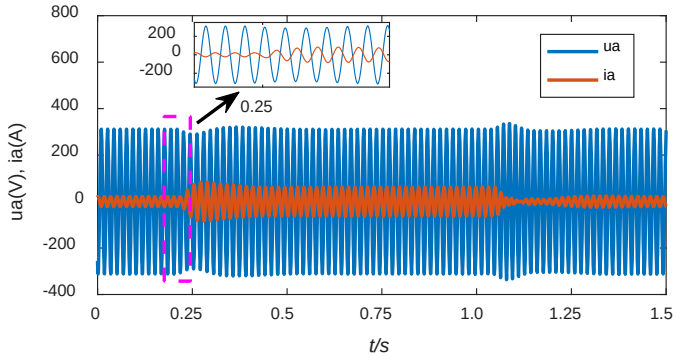

Figure 5. Super-Twisting Sliding mode control curve under sudden load change

From the simulation results, it can be seen that compared with the traditional PI control method of voltage outer loop current inner loop, the super twisting sliding mode control method reduces the rectifier voltage overshoot, has little difference in the dynamic regulation time, accelerates the response speed of electromagnetic torque, and quickly converges to zero for the electromagnetic torque and the sliding surface of flux linkage and its derivative. It is shown that the super twisting sliding mode control method can effectively improve the system's anti impact load capacity.

4. Summary

Through the simulation results, it can be seen that compared with the traditional PI control method, the new super twisting sliding mode algorithm can significantly reduce the fluctuation range of rectifier voltage and the regulation time of electromagnetic torque. At the same time, it can be seen that when the speed is 1000r / min, the motor output voltage is low and the motor flux is not saturated. When the speed suddenly changes to 1800r / min, the torque is reduced and the flux reaches saturation at this time, the motor voltage will not increase and maintain the rated voltage, and the electromagnetic torque and flux sliding surface variables and their derivatives can quickly converge to zero. It shows that the super twisting sliding mode control method can effectively improve the robustness of induction motor power generation system under the condition of wide speed.

The simulation experiment verifies the correctness of the theory and lays a foundation for the next step of physical verification.

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