Simulation of Improved Autotransformer Step-down Starter

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Abstract. The autotransformer step-down starting is characterized by the large impact current and the small short-circuit impedance of autotransformer. Therefore, the improved autotransformer step-down starter is presented in this paper. The following works have been done in the study: topology structure of the improved autotransformer step-down starter, modeling of the improved autotransformer step-down starter, and simulation. The simulation results show that the twice surge of improved system is smaller than the traditional system in the process of starting.

Introduction

In recent years, with the development of industrial production scale, motor industry in China rapidly developing towards the direction of the large capacity. As the motor power increases, the impulse current of motor will be greater while starting. It does great harm to the starting device, and also causes damage to the power system[1][2].

To solve the problems in the starting process of motor, the improved autotransformer step-down starter is presented in this paper. The system will not only limit the starting current amplitude, prolongs the motor working life, reduce the damage to the load, but also can reduce the power loss, prolong the working life of the other electrical equipments, reduce the energy consumption, reduce the cost of electricity, promote the economic benefits[3][4].

Based on the previous research, the following works have been done in the study: topology structure of the improved autotransformer step-down starter, modeling of the improved autotransformer step-down starter, and simulation.

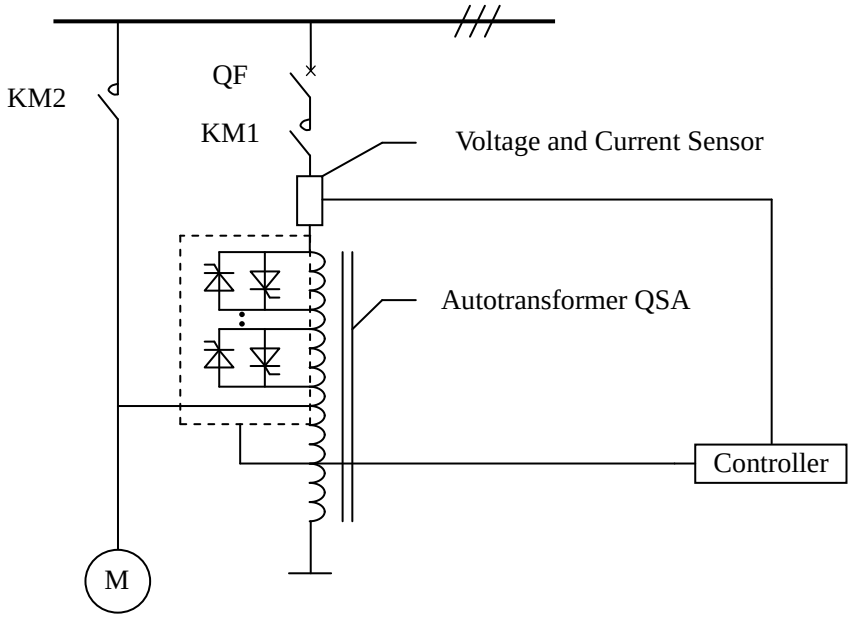

Fig.1. Topology structure of the improved autotransformer step-down starter

Topology structure of the improved autotransformer step-down starter

Power electronic switch is also called contactless switch. It is a controllable power switch and composed of power electronic devices[5]. Autotransformer step-down starter will change when the structure of the autotransformer is changed by power electronic devices. As shown in Figure1, the improved autotransformer step-down starter consists of 3 parts: autotransformer with power electronic switch, three-phase AC motor, and controller. N-groups of thyristors are parallel to the non-public winding side. Making them conduct in turn by send trigger pulses to each group of them through controlling circuit respectively. Motor starting voltage jumps n times and the voltage step amplitude is reduced. At the same time, the impact of the secondary shocks is lower.

Modeling and simulation of the improved autotransformer step-down starter

Taking the 7.5kW motor as the simulation object in this paper, and the improved structure of autotransformer step-down starter is used to establish the model of the improved system. On based of the SimPowerSystem library in Simulink in Matlab, the equivalent model of autotransformer, induction motor, and controllers are established, and then builds the entire system and simulates it.

Modeling of the autotransformer step-down starter. For the start system paralleling one group of thyristors, the simulation model is shown in Figure2.

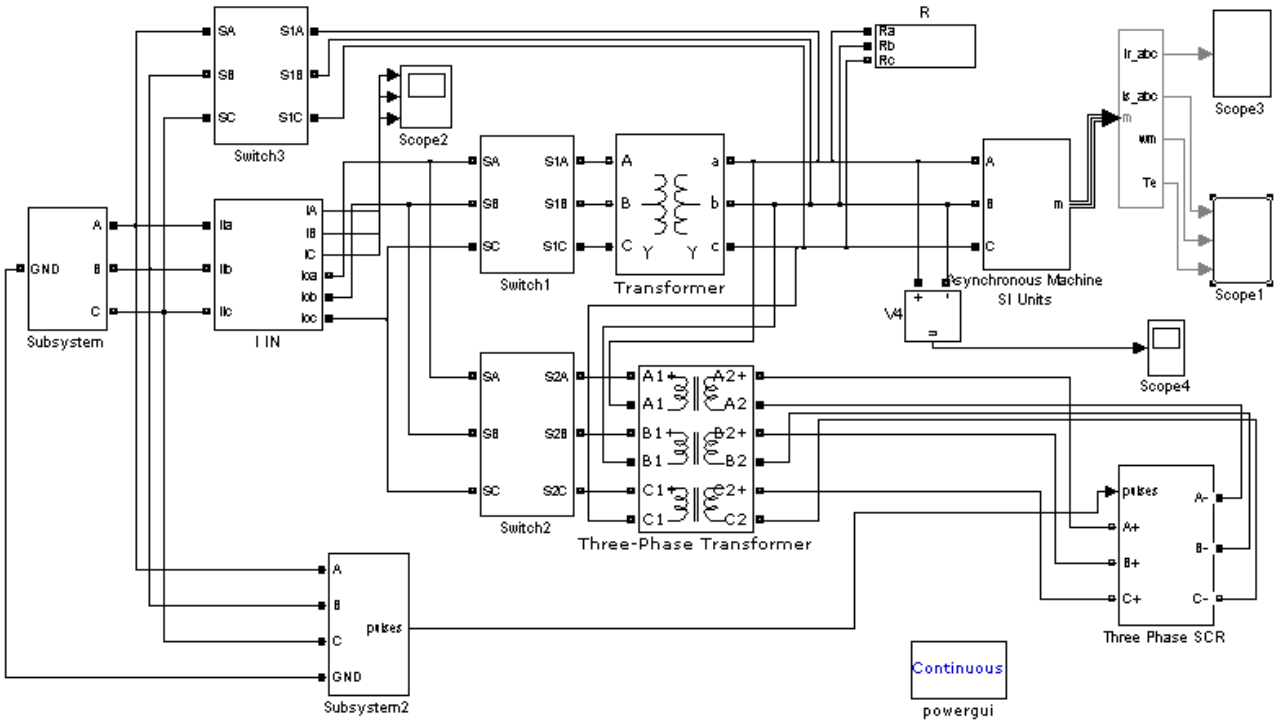

Fig.2. The model of improved autotransformer step-down starter

Switch is a three-phase circuit breaker module. The initial state of Switch1 is closed and disconnected on 0.4s, the initial state of Switch2 is disconnected and closed on 0.4s, and the initial state of Switch3 is disconnected and closed on 0.8s. Motor starting process is as follows: the motor autotransformer step-down starts during 0~0.4s, the thyristors module will be put into work during 0.4~0.8s, and the motor accesses grid for full voltage starting after 0.8s. The motor voltage jumps 2 times during the whole process. If the trigger angle is 0 degree, The thyristors will keep conducting to reduce the primary side equivalent input impedance of transformer. It will cause increasing motor starting current and voltage.

Simulation of the Autotransformer step-down starter. The simulation result is carried out with Matlab. The simulation time is 3s. The parameters of Transformer, Three-Phase Transformer and Asynchronous Machine SI Units are shown in Table1.

Tab.1. Parameters table

Transformer	Nominal power Pn(VA)	50
	V1 Ph-Ph(Vrms)	380
	V2 Ph-Ph(Vrms)	140
Three-Phase Transformer	Three-phase rated power(VA)	10
	Phase voltage(Vrms)	200
	Phase voltage(Vrms)	100
Asynchronous Machine SI Units	Nominal power Pn(VA)	7.5
	Voltage (line-line) Vn(Vrms)	380
	Stator resistance Rs(ohm)	0.782
	Stator inductance Lls(H)	0.0039968
	Rotor resistance Rr'(ohm)	0.943
	Rotor inductance Llr'(H)	0.0039968
	Mutual inductance Lm (H)	0.07987
	Inertia J(kg.m^2)	0.60
	Friction factor	0
	Pole pairs	2

The simulation results are shown in Figure3.

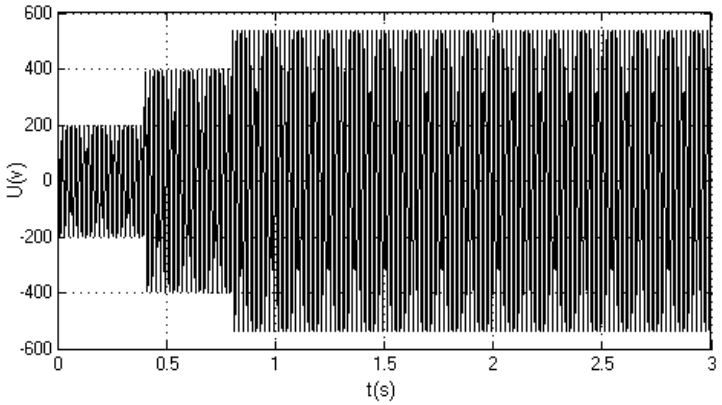

Fig.3. Motor starting line voltage waveform

As shown in Figure3 and Figure4, the step-down starting finished at the 0.4s.Then the group of thyristors in parallel with transformer conduct. The motor current is not directly increase to the rated value. It rises to an intermediate value at 0.8s. After that, the switching devices stopped working, motor accessed network and worked with full voltage. The current rises to rated value. Compared with the traditional starting system, the secondly surge of current was reduced. As can be seen from Figure6, the starting torque mutation of motor is also smaller. In Figure7, the motor starting voltage jump 2 times, the average jump amplitude is less than the traditional autotransformer step-down starter each time. It is proved that the improved autotransformer step-down starter reduces the abrupt change of torque and voltage.

Conclusion

There are shortcomings in the traditional autotransformer step-down starter, such as the twice surge and the large impact current. So the improvement of autotransformer step-down starter topology structure is proposed by authors. The following works have been done in the study: topology structure of the improved autotransformer step-down starter, modeling of the improved autotransformer step-down starter, and simulation. The simulation results show that the twice surge of improved system is smaller than the traditional system in the process of starting.

Acknowledgement

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