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Research on Performance Test of Generator Excitation System

Xiaohui Shen[a], Yanxun Wei[b]
CNNP Nuclear Power Operations Management Co., Ltd. Haiyan, Zhejiang, 314300, China
[a]yuko1228@163.com, [b]weiyx@cnnp.com.cn

Keywords: synchronous generator, three-machine brushless excitation system, automatic voltage regulator (AVR), performance test.
Abstract. With the change of the large power grid's security and stability situation, the technical requirements of the power plant excitation system modeling and power system stabilizer (PSS) setting are continuously improved. In order to analyze the operation status of the excitation system of the grid-connected unit, and ensure the operation condition of the excitation system meet the requirements of the power grid. The performance test of Qinshan Phase II Nuclear Power Station excitation system was carried out in this paper, which proved the regulation performance of automatic voltage regulator (AVR) and confirms the rationality of the parameters. Moreover, this paper provided a theoretical evidence and practical foundation for the stable operation of the unit.

Introduction

Generator excitation system is an important part of synchronous generator. It can track the field current of the exciter before grid connection and track the terminal voltage of the generator after grid connection. On this basis, it can steadily provide the field current to the synchronous generator not only from no load to full load, but also overload. Besides, it can maintain the generator terminal voltage at a given level, adjust the reactive power distribution, improve the safety and stability of power system operation, and ensure the reliability of power quality [1]. When the voltage drops because of some power system fault, the excitation system should be able to quickly forced excitation to improve the system stability. When a short circuit fault occurs in the synchronous generator, it is necessary to quickly eliminate the excitation to troubleshooting and limit the fault to a minimum range [2].

Unit 1、2 of Qinshan Phase II Nuclear Power Station use MEC5230 digital dual-channel automatic voltage regulator (AVR) manufactured by Mitsubishi Corporation, which is the three-machine brushless excitation system with high initial response. PID+PSS control mode is adopted.

The performance of excitation system depends on the parameters. The proper parameter setting can improve the system stability and increase the damping of the system. However, the improper parameter setting may bring threat to the safety and stability of the unit and power system [3].

As the large power grid's security and stability situation changes, the technical requirements of the power plant excitation system modeling and power system stabilizer (PSS) setting are continuously improved. Thus, in order to analyze the operation status of the excitation system of the grid-connected unit, and ensure the operation condition of the excitation system to meet the requirements of the power grid. This paper carried on the performance analysis of Qinshan Phase II Nuclear Power Station excitation system to prove the regulation performance of AVR and validate the rationality of the parameters.

Brushless Excitation System

Generator excitation and voltage regulation adopt the coaxial brushless excitation. Its role is to guarantee that the excitation can build the rotor rotating magnetic field, adjust the required no-load voltage for synchronization before the generator is connected to the grid, and regulate the reactive power exchanged with power gird after grid connection, so as to maintain a constant generator terminal voltage.

Meanwhile, the excitation system can monitor the field grounding for generator and exciter, and limit the current of rotor and stator to guarantee the stable operation of the generator and prevent overheating, so as to ensure the safety of generator and the quality of output power.

Excitation system is an automatic control system composed of synchronous generator, power unit and AVR. The basic block diagram is shown in Fig. 1. AVR detects the voltage, current or other state value of generator, and then sent a control signal to power unit according to the given regulation criterion, so as to realize the control function.

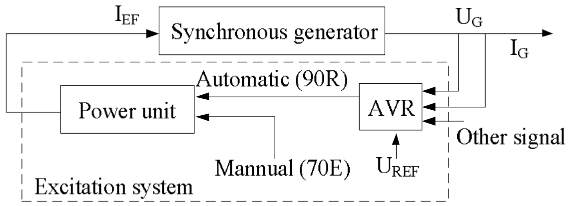

Fig. 1 The structure diagram of excitation system

Three-machine brushless excitation system consists of a 400Hz three-phase AC permanent magnetic generator (PMG) with a permanent magnetic rotor and a fixed stator. The 400Hz three-phase AC output from the PMG stator is rectified under the control of the AVR, and its DC output is supplied to the field coil of the main exciter.

There is also a main exciter with a 200Hz three-phase AC rotating armature and a static DC magnetic field, which supplies power to a rotary rectifier (diode rectifier bridge). The 200Hz three-phase AC output from the main exciter armature coil is supplied to the rotary rectifier for rectification. The DC output from the rotary rectifier is supplied to the generator rotor coil through conducting rod, thereby providing the generator field current so that the electrical power output from generator can meet the requirement. The control principle is shown in Fig. 2.

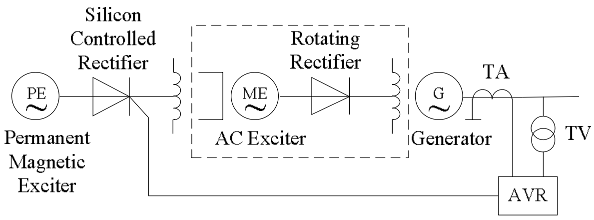

Fig. 2 The control principle of the excitation system

Model of Excitation System

AVR is the host-standby dual-channel excitation regulator, using PID+PSS control method. According to the control principle and logic provided by the equipment manufacturer, the block diagram of the excitation system is shown in Fig. 3 [4].

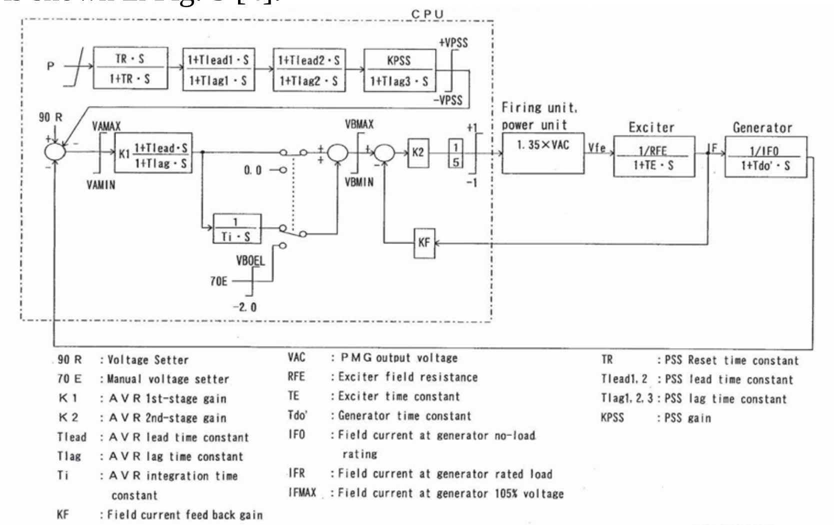

Fig. 3 Excitation system PID+PSS transfer function block diagram

Experiment Results

(1) Generator No-load Characteristic Test

In the no-load characteristic test, the generator voltage was raised to 120% of the rated voltage without the main transformer.

The no-load characteristic curve was shown in Fig. 4 according to the no-load characteristic data measured in field test.

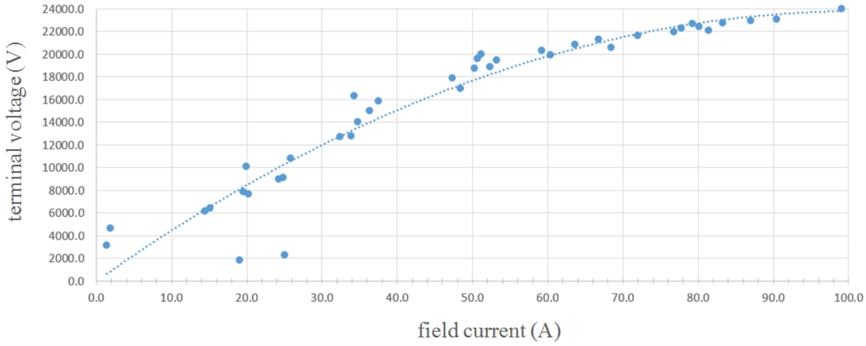

Fig. 4 Measured generator no-load characteristic curve

(2) Generator No-load Step Response Test

Raise the generator voltage to 95% of the no-load set value by excitation regulator, and carry out 5% step response test. The recorded wave is shown in Fig. 5.

In the 5% step response test, the oscillation number of the generator voltage is 1.0 time, over shoot M_P is 28.1%, rise time T_{UP} is 0.21s, peak value time T_P is 0.55s, adjustment time T_S is 0.85s. All the performance indicators of no-load step response meet the requirements of the national standard and the industry standard.

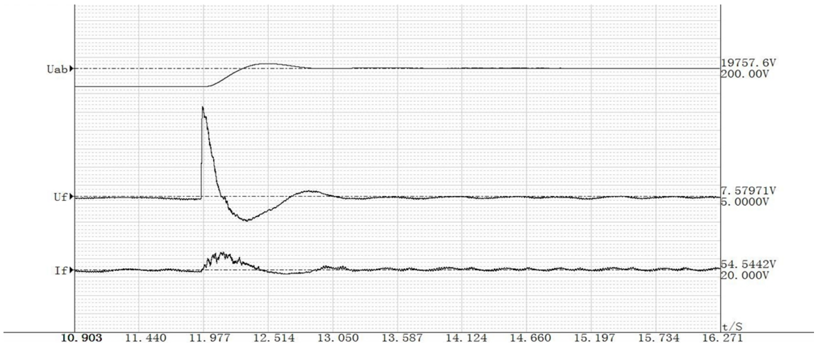

Fig. 5 Generator no-load 5% step response curve

(3) Generator No-load Large Step Response Test

Regulate the generator voltage to 15370V by AVR (the anode voltage of the silicon controlled rectifier is 295V when the terminal voltage is 75% of the rated). At this time, carry out 20% step test and record the response curves of stator voltage U_{ab}, field voltage U_f and field current I_f as shown in Fig. 6

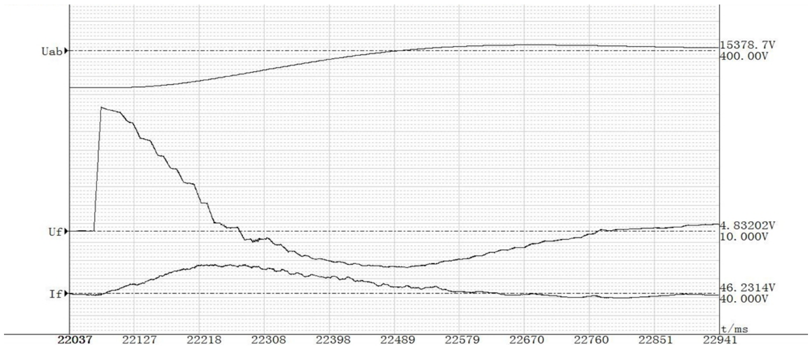

Fig. 6(a) Generator no-load large step up curve

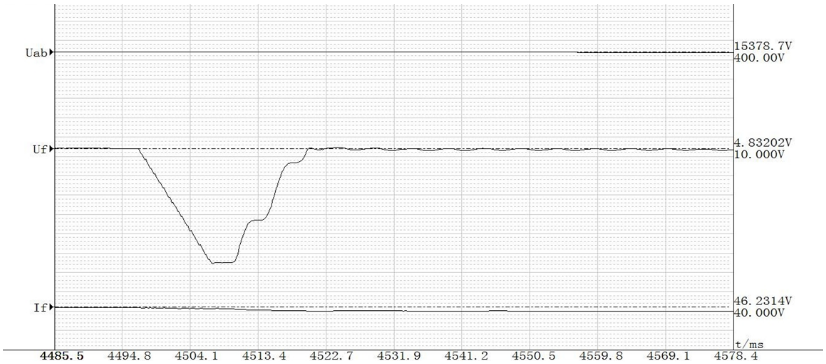

Fig. 6(b) Generator no-load large step down curve

(4) Generator Adjustment Polarity Test

Generator grid-connected operation, load is stable, excitation regulator is in automatic operation, and the given value of the terminal voltage remains constant. Rapidly and respectively adjust the adjustment coefficient to 0%、5%、0%、-5%、0%, record the test results of reactive power, terminal voltage, rotor voltage and rotor current as shown in Fig. 7.

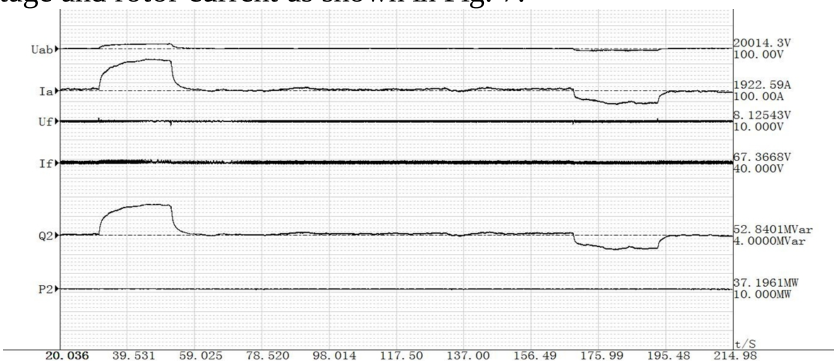

Fig.7 Record of adjustment polarity test

As can be seen from Fig.7, the adjustment polarity of AVR is opposite to that of the national standard. The adjustment coefficient of our AVR is set to 0%, which is equivalent to -0% in national standard.

Conclusions

In this paper, the performance test of the excitation system of Qinshan Phase II Nuclear Power Station was carried out. During the test, all the states of the unit were normal, and the data and curves of each parameter were correct. The test results verified the good regulation performance of AVR, and provided sufficient theoretical basis and practical foundation.

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