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To cite this article: Min Liu *et al* 2020 *IOP Conf. Ser.: Earth Environ. Sci.* **558** 052028

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Research on interconnection power system Construction of traditional energy Control Structure

Min Liu¹, Yanxi Zhang², Dongwen Yan³

¹School of Physical Science and Technology, Yangzhou University, Yangzhou, Jiangsu, 225000 China

²Electrical Engineering, University of Western Australia

³School of Intelligent Equipment, Shandong University of Science and Technology, Taian, Shandong, 271000 China

Abstract. With the increasing proportion of new energy in the power system energy. It has become an inevitable trend for new energy grid connected to participate in power system frequency modulation. As the representative energy of new energy, wind power has become the research focus of frequency modulation with traditional energy in recent years. In order to realize the frequency stability of power system, the load frequency control technology is used for power system frequency modulation at this stage. That is to say, in the case of any load disturbance, the power system can realize the load disturbance following the random change of power generation, so as to maintain the frequency deviation within a allowable range ($\pm 0.2\text{Hz}$). Based on this purpose, this design starts from the load frequency control model of conventional units, and first does not consider the role of wind power to build the control structure of traditional energy. In order to facilitate the study of the design of traditional energy units are selected thermal power units. Starting from the establishment of power system frequency response model, we can understand the composition of traditional energy power system frequency response model and the structural characteristics of multi regional interconnected power system. The characteristics of load frequency control module of governor, turbine, generator, load and other basic conventional units are analyzed, and the related transfer function is listed. After the completion of the basic module, the mathematical model of traditional energy single area and traditional energy two areas is built. At the same time, when considering the construction of two regional interconnected thermal power units, we should also pay attention to the characteristic analysis of tie line power and regional control deviation.

1. Introduction

For a long time, the traditional power industry is based on coal, oil and other related chemical energy. The power generation of hydropower, wind power and renewable energy accounts for a relatively small proportion. The increasing depletion of fossil energy and the serious deterioration of the ecological environment have become the bottleneck restricting the further development of the power industry [1]. As a result, a new energy revolution is rising rapidly. Its core is to change the mode of production and consumption of energy and reduce the dependence on traditional fossil energy.



The increase of new energy means that the operation mode of power system is also changed. The formation of new generation power system has more uncertain factors than the traditional energy system in terms of control mode and structure. Under the influence of uncertain factors, grid side and load side have higher requirements on power system stability in power transformation, power transmission, and power quality and safety. The integrity and relevance of the network, the source and the Netherlands also need to be further strengthened. However, maintaining the frequency stability of the new energy system after grid connection becomes the most urgent problem to be solved.

On the one hand, from the perspective of conventional frequency regulation in traditional energy system, these conventional units are restricted by their prime mover characteristics, that is to say, there are many problems such as limited frequency regulation range, insufficient reserve capacity and environmental constraints in frequency regulation by changing the inflow and inflow of steam turbine or water turbine of generator unit or water turbine. For example, the thermal power unit has the disadvantages of slow response speed / low ramp rate in frequency modulation, and the quality and flexibility of frequency modulation are difficult to meet the requirements [2]. On the other hand, with a large number of new energy connected to the power grid, the power grid reduces the power system rotation inertia and primary frequency modulation resources, resulting in the increase of frequency fluctuation during the operation of the power grid, so it is unable to maintain the dynamic balance between the active power provided by the power grid and the power required by the load. In the new energy grid connection, wind power and photovoltaic power generation account for a prominent proportion, while in the grid connection frequency control, wind power grid connection and photovoltaic grid connection have a significant impact on the power system [3-4].

According to the current energy distribution trend and proportion, the coordination of new energy and traditional energy has become a research hotspot. In particular, wind power and hydrothermal power jointly participate in frequency control of multi area interconnected power system under frequency modulation. Therefore, it is of great significance to explore the frequency control of interconnected power system with wind power as the representative of new energy.

2. Traditional energy load frequency control model

The load frequency control model of the traditional energy interconnected power system is based on the traditional energy to control the power system frequency. The general structure of the model mainly includes the basic frequency modulation system of conventional thermal power unit, hydropower unit and the load model of power system. When the load disturbance occurs in the power system with conventional energy units, the load frequency control technology is based on the primary differential frequency modulation of the governor, and the controller carries out the secondary non differential frequency modulation to realize the balance of generating power and load power. In order to achieve the effect that the frequency of power system is maintained in the upper and lower range of power frequency 50Hz. This paper focuses on the study of load frequency control of traditional energy interconnected power system, and constructs a load frequency control model including thermal power units. On the basis of the analysis of the basic modules, the single area traditional energy thermal power load frequency control model and the two area thermal power load frequency control model are constructed.

2.1. Governor model

The governor is the main structure of the power system, and it is also the load frequency control (LFC) is one of the important parts of the model. The significance of the model construction is that in the power system frequency control, the output torque of the prime mover such as the turbine and the water turbine can not be adjusted automatically. Therefore, the control of the power system of the prime mover is the main role of the governor in the frequency adjustment process. The external load disturbance makes the balance between the electromagnetic power of the generator and the mechanical power output of the prime mover be broken, which further leads to the change of the kinetic energy of the rotor of the generator, so that the rated frequency of the generator deviates from

the system frequency. In view of the power elements entering the prime mover, the governor acts quickly. By adjusting the opening of the steam valve of the turbine, the output mechanical power of the prime mover is changed, and the primary frequency modulation of the power system under the action of the governor is completed.

The types of governor can be divided into mechanical type, hydraulic type and digital type. Its frequency modulation process and mathematical model are basically the same. The angle velocity of the system is measured by the measuring mechanism, and compared with the setting value, the difference is amplified and sent to the actuator. The actuator uses the hydraulic amplification principle to control the opening of the steam valve of the steam turbine. Therefore, in the power grid load frequency control, it can be compared with a comparator. The output of the governor is the difference between the power setting value and $\Delta f/R$. The output command of the governor needs to be amplified by the hydraulic amplifier, It is transmitted to the opening position of the steam valve of the non reheat steam turbine to issue instructions, i.e. the transfer function of the governor composed of the control quantity, frequency deviation and valve regulation value is:

$$\Delta X_g(s) = \frac{K_g}{1+sT} [\Delta P_c(s) - \frac{1}{R} \Delta f(s)] = G_g(s) [\Delta P_c(s) - \frac{1}{R} \Delta f(s)] \quad (1)$$

Equation (1) reflects the dynamic characteristics between control command, regulation and system frequency. The governor structure diagram is shown in Figure 1:

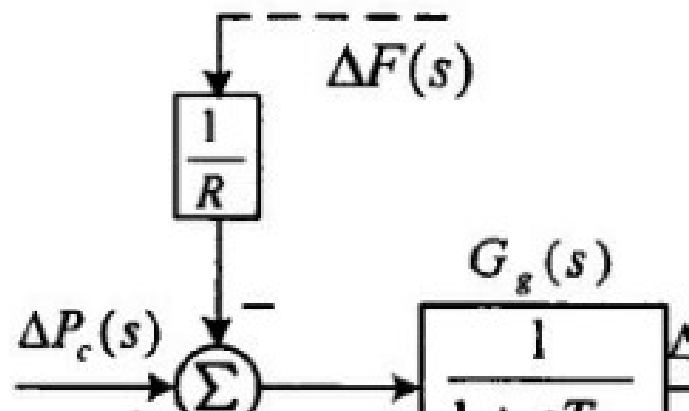


Figure 1 governor model

2.2. Motor model

The prime mover model of traditional energy LFC system includes steam turbine and water turbine. For the turbine, the valve position ΔX_g changes the amount of steam entering the turbine, resulting in a change in the turbine output power ΔP_T .

The steam turbine is divided into reheat type and non reheat type, the difference is whether the reheat charging delay is considered. In this design, non reheat steam turbine is used to build the model. Because steam turbine usually has the phenomenon of steam volume, that is, when opening and closing the steam valve, the space pressure between the regulating steam port and the first stage nozzle of the short-time steam turbine will not change immediately, which will cause the change of mechanical power to lag behind the change of the opening of the steam port, so the most basic first-order inertia link is usually used to express this phenomenon. This design adopts non reheat steam turbine To model

The transfer function of the non reheat turbine is:

$$G_T(s) = \frac{\Delta P_T(s)}{\Delta X(s)} = -\frac{1}{1+sT} \quad (2)$$

By combining the transfer function of the governor and prime mover listed above, the model block diagram of the non reheat thermal motor generator set consisting of governor and non reheat steam turbine is obtained as shown in Figure 2:

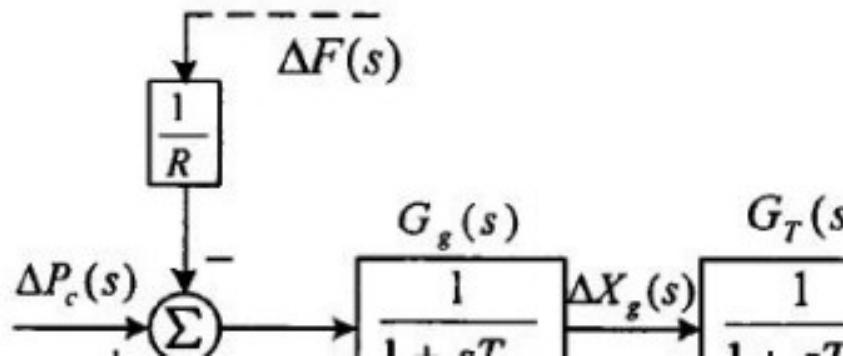


Figure 2 model block diagram of non reheat turbine generator unit

2.3. Tie line model

Tie line is an important part of the interconnected power system and only exists in the multi area load frequency control system. The existence of tie line is equivalent to different types of generator sets in each area to a certain extent. The subsystem is regarded as the related generator group, and does not appear in the whole multi area LFC system model framework with a simple single generator set. From another point of view, the existence of tie lines also facilitates the further expansion of the power grid scale. On the basis of increasing the regional interconnection of the power grid, the allocation of resources in each region is optimized. At the same time, maintaining the power stability of tie line has become one of the indexes of multi area load frequency.

There is only one tie line in the two area interconnected power system, so there is only one tie line power in the two area interconnected power system, and its transfer function is:

$$\Delta P_{tie}(s) = \frac{2\pi}{\omega} T_{12} [\Delta f_1(s) - \Delta f_2(s)] \quad (3)$$

According to formula (3), the block diagram of interconnection line between two regions is as follows:

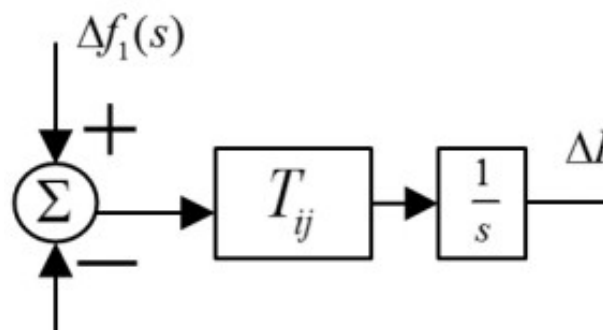


Figure 3 model block diagram of two area connecting line

2.4. Generator load model

For the establishment of the generator model, the generator set in each region can be equivalent to a generator group module, that is, the active power regulation in this region is not only carried out by one generator set, the mechanical power changes and load power changes generated by the turbine, the tie line power in other regions will be input into the large power grid under the generator group equivalence, and the controller in this region will Adjust the frequency. On the other hand, for the construction of load model, at present, the change of load is generally divided into three components: random, pulsation and duration according to the frequency. In this design, step load disturbance is selected for the convenience of analyzing load disturbance in the construction of traditional energy. The transfer function of generator load model in multi region is as follows:

$$G_{pi}(s) = \frac{K_{pi}}{1 + sT_{pi}} = \frac{\Delta f_i(s)}{\Delta P_{pi} - \Delta P_{pi}(s)} \quad (4)$$

For the generator load model with single area control structure, the input of tie line power deviation is reduced compared with that of multi area system, so the transfer function is no longer listed separately. The input of power system generator load model consists of three parts: mechanical power of turbine, load disturbance, and tie line power with other interconnected areas. After the generator module, the final output frequency deviation of power system.

3. mathematical model of interconnected power system between thermal power and thermal power

Based on the establishment of the closed-loop regulation structure of single area thermal power, the traditional two area interconnected power system model is built. The two area thermal power interconnected power system is a parallel operation of two single area thermal power. In the two area control system, in addition to eliminating the steady-state error, i.e. frequency deviation, through integral control, the steady-state error of the tie line power, i.e. negative error of each area, is also required to be eliminated Be responsible for power or frequency adjustment in this area. These two changes together constitute area control error (ACE). The controller of two regions is input as control signal respectively, and the control deviation of region I can be expressed by formula (5):

$$ACE_i = B_i \Delta f_i + \Delta \quad (5)$$

According to the above construction of the related plate model of the traditional interconnected power system model of thermal power units and the related power system frequency response model, the traditional two area thermal power interconnected power system model block diagram shown in Figure 4 is obtained. This design structure adopts the idea of decentralized control, and two controllers are selected to control two thermal power units separately, and on the basis of this structure Increase the interconnection constant relationship between zone 1 and zone 2, i.e. tie line power.

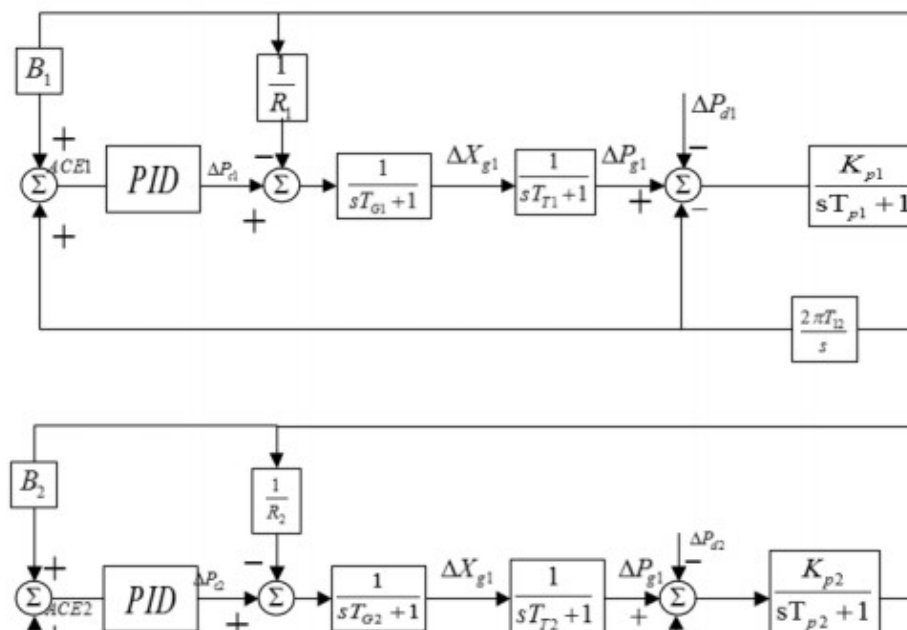


Figure 4 block diagram of thermal power thermal power regulation in two regions

The control system of traditional two area interconnected power system includes PID controller and governor. The regulating process is: when the load disturbance of the power system increases, the electromagnetic power from the generator does not match the mechanical power output by the prime mover, which leads to the decrease of the system frequency. At this time, the governor increases the valve opening of the turbine, increases the input power of the generator, thus inhibiting the decrease of the frequency. This process is the primary frequency modulation of the power system.

But the governor can only realize differential regulation. If the load disturbance increases, the controller will play a role at this time. Through the load frequency control technology, it can adjust without difference. In the whole regulation process, it can control the input area to control the deviation through the controller. Ensure that the frequency deviation, area deviation and tie line power deviation are within the allowable range of regulations.

4. Conclusion

In the new energy participating in load frequency control, wind power has become the most widely used and fastest developing new energy power generation mode. Because of the fluctuation and unpredictability of the wind farm output power, it has a significant impact on the power system frequency control. In this paper, the main research content is to build the frequency control model of the interconnected power load of the traditional energy thermal power, and take the research of the frequency response model of the power system as an opportunity to build the transfer function of the governor, prime mover, generator, etc. On the basis of single region, the structural deviation of interconnected power system with two regions is studied, and the control objects of regional thermal power system and two regional thermal power system are distinguished. Distinguish the basic concepts of tie line power and regional control bias.

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