Load Frequency Control in Hydro Thermal Power system

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Abstract: The significant role of an Electrical power in the life of community is to develop numerous segments of economy. Today, the current economy is entirely in need of electricity as a rudimentary unit. The technical rebellion moves every feature of current life. Rapidly emerging computer skills are altering the work atmosphere for power causes working by values and producers. Developing computer software allows quite precise project of power system components or networks and amenities, more urbane operational approaches that effect in high system dependability. Though computational methods have showed valuable in overall purpose of optimization, these seem mainly pertinent for addition of non-linearly constrained optimization issues.

Keywords: Load Frequency Control, Multi Area, Speed Governor.

1. Introduction

Load Frequency Control (LFC) issue is the extreme critical and novel arena of investigation in interrelated power systems has a profound past in the power system process. The generators functioned in service zone swing the speed steadily for corresponding the power angles and frequency to precise quantity of fixed and enthusiastic circumstances together. It is obligatory to accomplish the frequency at definite and adequate restrictions but nonstop dissimilarity in load can’t be overlooked due to instable nature. A moral load frequency control system has the ability to equilibrate the tie line power and system frequency within their limits.

2. Load Frequency Control in Multi Area Power System

The load turbulences are extremely influencing the power system procedure. Daily high power load intake origins frequency deviation makes the system unstable. LFC also known as AGC supports to dazed the overhead difficulty by its fast acting tactic as explained [32] The LFC contains two paths i.e. primary control path that meets the demand with production and secondary control path for satisfactory alteration of frequency. Speed governing mechanism acts as primary control loop which is a fast acting loop to retain the frequency during the power mismatch.

The free governor action will make the governor output to match in meeting the additional load thus attaining the equilibrium. But the speed drop of the generator units is limited to 2-3% which makes the generator, frequency sensitive. Due to this limitation, at the expense of frequency deviation to a new value being attained by the governor action, driving the generator output, meeting the demand power, maintain the
system secured. Thus LFC helps to keep the system frequency inside the prescribed parameters, irrespective of sudden change of load.

The response speed depends on usual time intervals of turbine and systems which may be of 2-20 seconds depend on the type of the turbine. Though, the speed governor matches the requirement with production and found incline in frequency. Fine tuning of system frequency i.e. reorganizing the frequency fault to zero is achieved by slow acting tributary controller which would respond in minutes as explained [30].

For developing the ideal tributary controller, precise mathematical model of two areas along with the power system is essential. This paper designates about modelling of hydro thermal areas with its interconnection. Such a transfer function model will enable the development of optimal secondary controller.

3. Thermal Power System

In Thermal area as explained [35], the turbine turns as prime mover for generator which receives the mechanical power from boiler via steam. If there is growth in requirement, then there is variation in frequency due to mismatching among requirement and supply. On the basis of frequency, the speed governor by using hydraulic magnifiers alters the creek valve of steam that regulates the frequency.

3.1 Transfer Function Model of Thermal Power System

The constituents of Thermal area i.e., speed governor; steam turbine; hydraulic amplifier and power system are modelled as single order time constant for doing small signal analysis [22].

![Fig. 1: Thermal power system Transfer function](image)

The inputs to speed governor are reference power settings ($\Delta P_{\text{ref}1}$) and change in frequency ($\Delta f_1$). The output of the speed governor regulates the steam which act as input of turbine as per petition requirement. The block diagram of speed governor is given in Eqn. (1) as:

$$\Delta P_g = \Delta P_{\text{ref}1} - \left(\frac{1}{R_1}\right) \Delta f_1$$

(1)

The speed governor fails to operate against high pressure steam. Therefore, with various phases of hydraulic magnifier, large mechanical forces positions the gate valves of the turbine against extraordinary pressure steam. The transfer function of hydraulic amplifier is conveyed in Eqn. (2) as:
\[
\Delta P_v = \left(\frac{1}{1+sT_H}\right) \Delta P_g
\]  

(2)

In this research, non-reheat turbine is measured as the prime mover. The equation, which explains turbine operation, is furnished in Eqn. (3) as:

\[
\Delta P_T = \left(\frac{1}{1+sT_T}\right) \Delta P_v
\]  

(3)

The output powers of turbine energies the generator that gives an electrical power to the scheme whose transfer function is revealed in Eqn. (4) as:

\[
\Delta P_T - \Delta P_{D1} = \left(\frac{K_{P1}}{1+sT_{P1}}\right) \Delta f_1
\]  

(4)

4. HYDRO POWER SYSTEM

In Hydro areas [14], the main source for generating mechanical energy to run the turbine is water. As less time is required for ignition, greater time period succeeds in reaction during regular operation because of huge water inertia. The unbalancing among requirement and supply is identified with respect to alteration in frequency by the governor [19] which regulates the input of water to turbine.

4.1 Transfer Function Model of Hydro Power System

The mathematical model of the arrangement with speed governor, hydro governor and power system is published as a report [7] and its transfer function is shown in Fig. 2.

\[
\Delta P_{HV} = \frac{1+sT_R}{1+sT_2} \Delta P_{Hg}
\]  

(5)

Where \(\Delta P_{Hg} = \frac{K_1}{1+sT_{Hg}} (\Delta P_{ref2} - \frac{1}{R_2} \Delta f_2)\)

5 Tie-Line

The transfer function of Thermal and Hydro area as expressed in Fig. 1 and Fig. 2 are considered to be a control area assuming that the area contains either Hydro or Thermal power plant alone and they are in
coherent operation. All the generators, turbine and speed governor in a control area has similar characteristics and they are said to be operating in coherent.

5.1 Model of Tie-Line Transfer Function

Tie-line is a medium which joins two areas and the power flow among line is based on contract between the areas which is articulated in Eqn. (6) as;

\[ \Delta P_{tie12} = \frac{2nT}{s} (\Delta f_1 - \Delta f_2) \]  

(6)

The model of tie-line transfer function [16] expressed in Eqn. (6) is expressed in Fig. 3.

Fig. 3: Model of Tie line Transfer Function

6. Hydro Thermal Power System

In practice, the power system consists of both Thermal and Hydro power plant. For last four decades, the researches connect the Thermal and Hydro area as expressed in Fig. 5 and recently research is reported [18].

Fig. 4: Schematic diagram of Hydro Thermal system

Fig. 4 shows that the Area1 has only Thermal power plant in coherent. Similarly, Area2 contains only Hydro plant in coherent which are connected through tie-line. Both the areas can be imperiled to load changes. When there is growth in load in one area that will be supplied by the same area and by using tie-line supplied by another area But actually, a control area has both Thermal and Hydro areas as shown in Fig. 5 which is not considered by the researchers.
Fig. 5: Schematic diagram of Multi Area Hydro Thermal system

The Hydro Thermal scheme revealed in Fig. 5 is alike to that of the scheme shown in Fig. 4. The only difference is that, each area has got both Thermal and Hydro areas. The interconnection operation is identical. In this work, the system shown in Fig. 4 is represented as Single Source Multi Area because of one source in each area, whereas the system shown in Fig. 3.5 is Multi Source Multi area due to two sources in each area.

7. Model of Two Area Hydro Thermal System Transfer Function

The model of two areas Hydro Thermal transfer function exposed in Fig. 6 is established using the transfer function of Thermal plant in Fig. 1, Hydro plant in Fig. 2 and tie-line representation in Fig. 3.
The total power generation in any zone is equal portion of generated power by hydro and thermal power plant in respective areas.

8. Conclusion

In this paper, transfer function model of Thermal Hydro power plant has been derived. They are associated together with the tie-line in two methods namely Two Area, which is conventional and then multi area which is new concept. On analyzing, the thermal system when subjected to unit step load up roar of 0.01 p.u. in Area1 alone, the area frequency and the tie-line power oscillates and settles with offset. The offset can be removed by including secondary controller which varies the power reference setting of the governor. An optimal secondary controller is to be developed for effective operation of hydro thermal power system.

REFERENCES

1. Karush, W., (1939), "Minima of functions of several variables with inequalities as side conditions", MS Thesis, Department of Mathematics, University of Chicago, Chicago, IL.

2. Courant, R., (1943), "Variational methods for the solution of problems of equilibrium and vibrations,


33 Reklaitis, G.V., Ravindran, A. and Ragsdell, K.M.,(1983) , "Engineering Optimization: Methods and


