Load Frequency Control of Single Area Power System by using Integral Control Action

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Abstract - In an interconnected power system, if a load demand changes randomly, both frequency and tie line power varies. The main aim of load frequency control is to minimize the transient variations in these variables and also to make sure that their steady state errors is zero. Many modern control techniques are used to implement a reliable controller. The objective of these control techniques is to produce and deliver power reliably by maintaining both voltage and frequency within permissible range. When real power changes, system frequency gets affected while reactive power is dependent on variation in voltage value. That's why real and reactive power are controlled separately. Control of load frequency controls the active power. The role of automatic generation control (AGC) in power system operations with reference to tie line power under normal operating conditions is analysed. This dissertation implemented load frequency control of single area power system by integral control action and modelled and simulated in this dissertation through simulation in the MATLAB-Simulink environment.

I. INTRODUCTION

The possibilities of enhancement of complex interconnected power system is to decrease the probability of black outs and enable an increasing power exchange among different system inside the large interconnect networks. For large-scale power systems, which normally consist of interconnected control area, Load Frequency Control (LFC) is important to keep the system frequency and the inter-area tie power as close as possible the scheduled values. The mechanical input power to the generators is used to control the frequency of output electrical power and to maintain the power exchange between the areas as scheduled. A well designed and operated power system should cope with changes in the load and with system disturbances, and it should provide acceptable high level of power quality while maintaining both voltage and frequency within tolerable limits [1].

The power system frequency control, as a major function of automatic generation control (AGC), has been one of the important control problems in electric power system design and operation. Undesired frequency deviations have direct impact on power system operation and system reliability [2]. A large frequency deviation can damage equipment, degrade load performance, cause the transmission lines to be overloaded and can interfere with system protection schemes, ultimately leading to an unstable condition for the power system [3]. The increasing number of major power grid blackouts that have been experienced in recent years [UCT 04, AND 05, MAK 05, SAN 07, SAR 12] for example, the Brazil blackout of March 1999, Iran blackout of Spring 2001 and Spring 2002, Northeast USA-Canada blackout of August 2003, Southern Sweden and Eastern Denmark blackout of September 2003, the Italian blackout of September 2003, the Russia blackout of May 2005, and the north-eastern Indian blackout of July 2012 shows the requirement of good and accurate power system controller. Maintaining frequency and power interchanges with neighboring control areas at the scheduled values are the two main primary objectives of a power system LFC. These objectives are met by measuring a control error signal, called the area control error (ACE), which represents the real power imbalance between generation and load, and is a linear combination of net interchange and frequency deviations. The LFC problem has been augmented with the valuable research contributions from time to time, like LFC/AGC regulator designs incorporating parameter variations/uncertainties, load characteristics, excitation control, and parallel ac/dc transmission links [4]. The small signal analysis is justified for studying the system response for small perturbations. However, the implementation of AGC strategy based on a linearized model does not necessarily ensure the stability of the nonlinear system. Considerable attention has been paid by researchers to consider the system nonlinearities to develop a robust controller.

II. AUTOMATIC LOAD FREQUENCY CONTROL

The successful operation of interconnected power systems requires the matching of total generation with total load demand and associated system losses. With time, the operating point of a power system changes, and hence, these systems may experience deviations in nominal system frequency and scheduled power exchanges to other areas, which may yield undesirable effects. In actual power system operations, the load is changing continuously and randomly [11]. The ability of the generation side to track the changing load is limited due to physical / technical consideration, causing imbalance between the actual and the scheduled generation quantities. This action leads to a frequency variation. The difference between the actual and the synchronous frequency causes mal operation of sophisticated equipment's like power converters by producing harmonics.

III. LOAD FREQUENCY CONTROL

In an electric power system, Load Frequency Control is a system to maintain reasonably uniform frequency, to divide the load between the generators, and to control the tie-line interchange schedules.

Load Frequency Problem: If the system is connected to numerous loads in a power system, then the system frequency and speed change with the characteristics of the governor as the load changes. If it's not required to maintain the frequency constant in a system then the operator is not required to change the setting of the generator. But if constant frequency is required the operator can adjust the velocity of the turbine by changing the characteristics of the governor when required. If a change in load is taken care by two generating stations running parallel then the complex nature of the system increases. The ways of sharing the load by two machines are as follow:

1) Suppose there are two generating stations that are connected to each other by tie line. If the change in load is either at A or at B and the generation of A is regulated so as to have constant frequency then this kind of regulation is called as **Flat Frequency Regulation.**

2) The other way of sharing the load is that both A and B would regulate their generations to maintain the frequency constant. This is called **parallel frequency regulation.**

3) The third possibility is that the change in the frequency of a particular area is taken care of by the generator of that area thereby maintain the tie-line loading. This method is known as **flat tie-line loading control**.

4) In **Selective Frequency control,** each system in a group is taken care of the load changes on its own system and does not help the other systems, the group for changes outside its own limits.

5) In **Tie-line Load-bias control** all the power systems in the interconnection aid in regulating frequency regardless of where the frequency change originates.

Mathematical Modeling of a Generator: With the use of swing equation of a synchronous machine to small perturbation, we have $\frac{2H}{\omega}\frac{d^2\Delta\delta}{dt^2} = \Delta P_m - \Delta P_e$ Or **in terms of small change in speed**

$$\frac{d\Delta\frac{\omega}{\omega_s}}{dt} = \frac{1}{2H}(\Delta P_m - \Delta P_e)$$

Laplace transformation gives,

$$\Delta\Omega(s) = \frac{1}{2Hs}(\Delta P_m(s) - \Delta P_e(s))$$

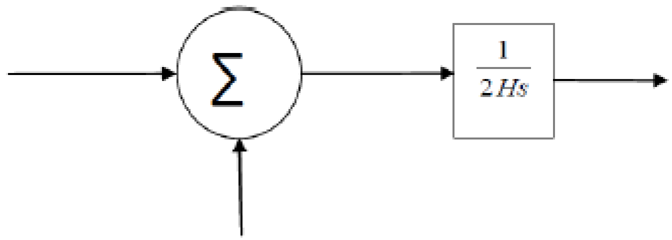

Figure 1: Mathematical modelling block diagram for a generator

IV. SIMULATION RESULT

By using simulation models, we can obtain the performance characteristics of the system very easily and quickly for analysis purposes. Below are the various systems Simulink models with their respective responses plotted against time. Here we considered single area systems.

Single Area System without using Secondary Loop: The plot in Fig. 5.2 which is obtained by simulating the model as shown in Fig.4.1 shows that the change in load causes alteration in speed and that causes deviation in frequency. From the plot, we are able to comprehend that the frequency oscillations will gradually stay down to a limited value.

The new-fangled operating frequency is supposed to be lesser than the nominal value. We have taken the values of the different parameters as shown in table 5.1 for modelling the Simulink model and its successful operation to obtain the desired results.

Single Area System by using Load Frequency Control without Integral Control Action:

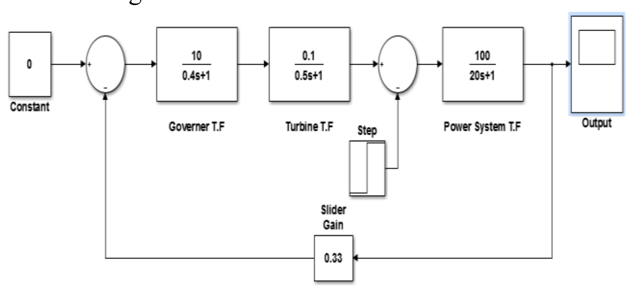

Figure 2: Simulink model for single area system by using load frequency control without integral control action

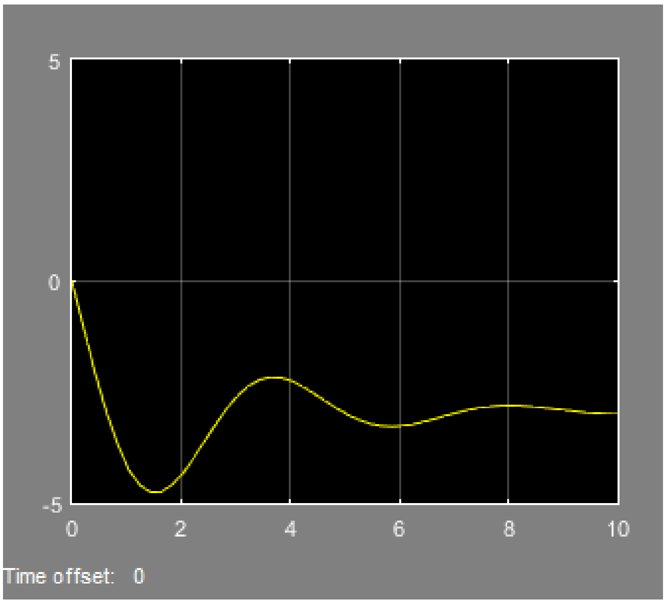

Figure 3: Change in frequency vs. time for single area system by using secondary load frequency control without integral control action

Single Area System by using Load Frequency Control with Integral Control Action:

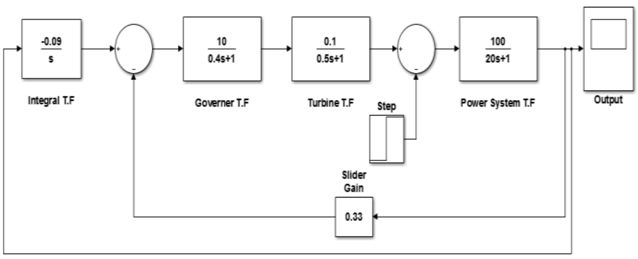

Figure 4: Simulink model for single area system by using load frequency control with integral control action

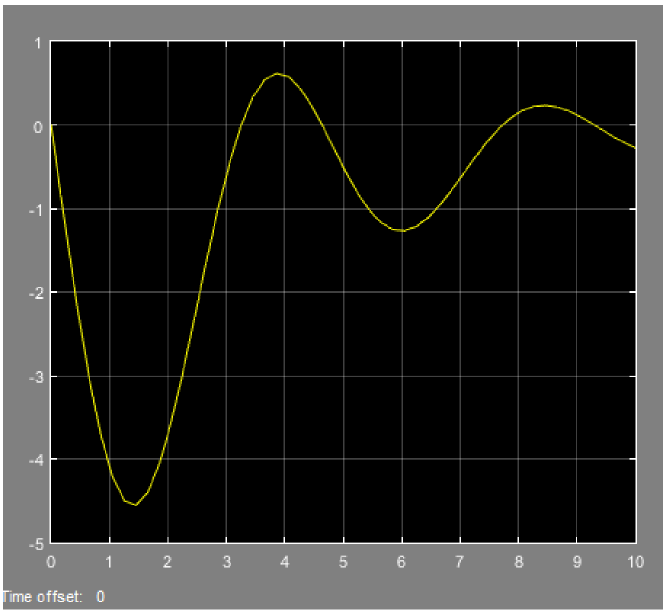

Figure 5: Change in frequency vs. time for single area system by using secondary load frequency control with integral control action

V. CONCLUSION

The thesis has chiefly investigated on the frequency change as well as change in the tie line power due to the change in the load and also the techniques that may be used for obtaining the optimized values of various parameters for minimizing the changes. Firstly, a secondary control is being introduced for minimizing the deviations in frequency. This is usually vital in case of a single area system or an isolated system as the secondary control loop i.e. an integral controller is generally responsible for reducing the changes in the frequency deviations and maintains the system stability. Therefore, without the presence of secondary loop the system losses its stability.

VI. FUTURE SCOPE

The Future Scope of this dissertation is that It may be implemented to system with two areas System.

VII. REFERENCES

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