School of Electrical and Electronic Engineering
Technological University Dublin

BE in Electrical and Electronic Engineering

Power Systems Operations and Economics

Power Frequency Control Assignment

INTRODUCTION

The objective of this assignment is to study the power frequency response of an isolated area and then a two-area system when subject to small disturbances. This involves the development of an appropriate simulation model, either in Matlab or Simulink. For the isolated system, the simulation model allows the variation in system frequency to be studied for variations in the system load. For the interconnected system, a linear model of two power system areas connected by a tie-line (or interconnector), is used to examine the variation of area frequency and tie-line power flow after load disturbance.

This is a team assignment and you will be allocated into a group. The team will be required to arrange the work allocation between the members as there are a number of aspects to the assignment. Each group will also be allocated an additional element to complete.

SYSTEM DETAILS

The system to be analysed is shown in Figure 1, representing two power system areas connected by a transmission line. Area A represents a thermal system and area B a hydro generation area. The investigations listed below are to be made using the Matlab/Simulink package. For each case, the appropriate Matlab program is to be developed. Alternatively, Simulink models can be developed to investigate the system. An example of a Matlab program for analysis of a single area without integral frequency control is available in Brightspace. Alternatively, an example of a Simulink model is also provided.

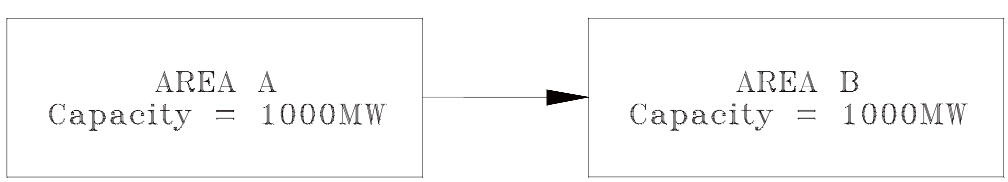

Figure 1: Interconnection of Two Systems

The details of the system are as follows:

Parameter	Area A	Area B
T_p/K_p	0.2	0.12
$D=1/K_p$	0.01	0.008
T_G	0.5	0.5
T_T	0.1	0.1
R	4% = 2.0 Hz/pu MW	4% = 2.0 Hz/pu MW
K_I	0.2	0.1

The interconnection capacity is 50 MW and therefore $T_{12} = 0.05$. Also, $\delta_1 - \delta_2 = -1.0$ rad.

MODEL DEVELOPMENT AND INVESTIGATIONS

a) Without the interconnection and without power frequency control (integral control) on areas A and B, determine the variation in frequency in each area when a load disturbance of -0.05 p.u. is injected into area A and +0.03 p.u. is injected into area B.

b) Without the interconnection but with power frequency control (integral control), repeat section (a) above.

c) Using the Matlab program/Simulink model developed above in Section (b) for a single system with integral control, plot the response of the system frequency for a step change in system demand for 5 different values of integral gain. Determine the value of K_I which will cause instability in the system.

d) Select one of the values of integral gain and calculate the time (clock) error resulting in such a system from a step change in demand of -0.05pu. Use the SUM function in the Matlab program or add an integrator in the Simulink program.

e) Develop the Matlab program or a Simulink model to represent the two-area system with the interconnector in place but without ACE control. Plot the response in area frequency and power flow between the areas for a step change in area A of -0.05pu and +0.03 in area B.

f) Add ACE control to the system in Section (e) to ensure that both the power flow between the areas and the frequency return to their pre-disturbance values. Select appropriate values of K_I (the integral control gain) and B (the frequency bias parameter) to obtain a reasonable response. Contrast this with the extreme cases of high values of K_I and low B and low K_I and high B.

g) Typical values for the parameters for a power frequency control model are presented earlier in the assignment. How would these values be determined in practice? Identify and summarise a study where these parameters are reported and/or determined. What conclusions do you draw?

ADDITIONAL ELEMENTS TO ASSIGNMENT

Based on the models which you have developed above, each group will be required to undertake one of these additional assignment elements. The additional element corresponds to your group identifier.

1. Plot the Root Locus of this system (using the RLOCUS function) and determine the value of integral gain which causes the system to become unstable. Calculate the frequency of oscillation of the system at which the system becomes unstable. Confirm this response using the time response of the system.

2. The interconnected system above requires you to develop a Matlab or Simulink representation of two systems connected via a transmission line. Describe how you would develop a system consisting of three interconnected systems. Demonstrate how such a system would respond to a load change in one area. Ensure that you implement controls to return the frequency deviation and the interconnector flow to zero.

3. The single bus system (similar to the isolated system above) is often used to represent a power system to allow for the investigation of system inertia on system performance. This is of particular interest as the inertia in power systems reduces due to the increase in wind generation penetration. Use the single bus system to demonstrate the effect of reducing inertia on the Rate of Change of Frequency (RoCoF). Why is the RoCoF such a significant performance measure in a power system? What are the implications of this situation in a system like the Irish power system?

4. As part of this assignment, we looked at the time error. Is the requirement to eliminate the time error still relevant in modern power systems? Give some examples from actual power systems. What are the typical limits on time errors in systems where it is monitored and contained? What are the implications of time errors in power systems?

Present your results in a report, addressing each of the sections and including relevant calculations as required. Ensure you state any assumptions made. Include references to any sources you use. Prepare a short presentation of your main findings. This presentation will be given to the group.

This assignment due on **Friday 18 February 2022.**

Michael Conlon
January 2022