1. An Introduction to Transient Stability

Aims

• To give an appreciation of the data required for transient stability studies
• To give experience on the use of a commercial package
• To gain experience of rotor oscillations during network changes
• To gain experience in determining critical clearing time

Introduction

This exercise will concentrate on using the transient stability function. Transient stability is concerned with the time response of the system when it is disturbed. Perturbations to the system can include faults, or items of plant being switched in or out. It is very important to power system operators to know that their system remains stable when transients occur. In the context of power systems, stable means that generators remain in synchronism with the rest of the system. We will examine several types of perturbation that need transient stability investigations.

Getting started

Log into ERACS, create new network and data state names. Create a library name for the network. In creating your network it will be necessary to copy the relevant data from the ERA_Reference library for the elements listed in the appendix 1. Input the system shown in figure 1. Run a system load flow to reflect the information shown in figure 2.

The main output from the transient stability calculation is a graph of a desired variable against time. We will choose the Hunts Bay B6 generator’s absolute rotor angle for our graph. Choose Calculate from the top row and then Transient stability from the menu list. Give the study a suitable title. Now change the following:

Study parameters: Study end time – 5

Reference generator — Grid 1 (select this by placing the cursor over grid and clicking the left-hand mouse button)

Network events: Choose Add, click the LH mouse button over CB1 and then change the Event type to open, applied at 0.1.

Plot parameters: Y scale: No of divisions 12, mm value 40, max value 70, label degrees.

Now choose Add from the bottom row of buttons, and click the LH mouse button with the cursor over the HBB6 generator. You will see a menu of plot parameters for HBB6.

Select absolute rotor angle by clicking the cursor in the empty box to the left of this parameter and, on the same line, set the minimum and maximum values to 40 and 70 respectively. Click OK at the bottom of this menu.

Now choose Run Study from the bottom LH of the Transient Stability Setup Box. Your graph should be identical to figure 3.

Note: there are two sets of minimum and maximum values set in Plot Parameters. The Y Scale set determine only the labelling applied to the graph, whereas values set alongside
the plot parameters menu options determine the scale with which the values are plotted. The labeling is entirely arbitrary since ERACS can simultaneously plot several graphs using different Y axis scales. If you are only plotting one graph, make sure that both sets of minimum and maximum values are set the same.

**Exercises 1**

Using the same data, increase the length of the transient stability study to 25 seconds — this will enable you to see the final rotor position after the transients have decayed. Run the simulation and print the graph.

Increase the real power of Gen I from 300 MW to 400 MW. Rerun the transient stability calculation. Print the result.

**Analysis:**

a) Why are the final rotor positions different from the starting position in each case?

b) Why does the initial rotor position vary when the load is increased?

c) Calculate the rotor oscillation frequency for each case (consider first cycle only) — are they different? What determines the frequency of oscillation?

**Exercise 2**

Set Gen 1 to 200 MW. Run the transient stability calculation for the following conditions (note: you may need to delete the switching out line 2 change; set the graph to -180° to +180°):

change 1: time = 0.1 seconds  Apply 3 phase fault on Bus 2

change 2: time = 0.4 seconds  Remove fault

study end time:  (i) 10 seconds
                 (ii) 20 seconds

Print the response and answer these questions:

a) Why does the rotor angle increase rapidly during the fault?

b) Why are the initial and final rotor positions the same?

**Exercise 3**

Repeat the exercise for a fault removal time of 0.7 seconds. Explain the shape of the curve. The critical fault clearing time is the particular value of fault clearing time for which the system ‘just’ remains stable. Use ERACS to find the critical fault clearing time for this condition.

**Exercise 4**

Adjust your network as shown in Figure 4. The figure shows the load flow results for the network. The new generator is similar to the HBB6 unit, with initial group assigned power of 200 MW. The line is also L400 and has a length of 150 units.

Rerun a stability study having a three phase fault at the grid bus and include plot parameters for the Old Harbour generator. Initiate the fault at 0.1 seconds and using your knowledge garnered from exercise 3 determine the critical clearing time. Adjust the group assigned power of the new
generator, in steps of 50MW, and determine the corresponding critical clearing time for the Hunts Bay generator.

What is the impact of additional generator export on critical clearing time?

Appendix

Plant Parameters

**GEN 1:** Generator type: PV, Park’s Equations
- Voltage magnitude = 1.0 p.u.
- Group assigned power = 300 MW
- Library Key: G860
- Generator model: Parks Model
- AVR Library Key: AIEEE1 (IEEE type 1) – A012
- Governor Key: S001 (type 1 Governor)

**Grid 1:** Voltage magnitude = 1 p.u.

**Line 1**
- Library Key: L400
- Length: 100

**Line 2**
- Library Key: L400
- Length: 10

**Circuit Breaker 1:** 400 kV

**Busbars:** 400 kV