Frequency Stability Analysis

Lab 5

EEEN50100 - Stability Analysis of Nonlinear Systems

Exercises

Consider the WSCC 9-bus 3-machine system with *d-q* axis machine models, AVRs and turbine governors and consider a loss of load at bus 6. Determine the effect on frequency variations and stability in the following scenarios:

1. The base case condition and a load increase of 25%.
2. The base case condition and a load increase of 25% with inclusion of frequency regulated loads (50% of the total load).
3. The base case condition and a load increase of 25% with inclusion of a storage device connected at bus 8.

Data File

Use the file `wscc_reg.dm` that can be found in the collection of data files on the module website.

Hints

- The time domain integration can be solved using the command:

  ```
  >> dome -r TDS wscc_reg.dm
  ```

  Help on available options can be obtained using the command:

  ```
  >> dome -A TDS
  ```

- Neglect the effect of secondary frequency regulators.
- Set `Settings.coi = True` for all simulations.
- To simulate frequency-regulated loads use the model `ThlCoi` and set `kp = 50`. Note that `ThlCoi` are used only *after* the power flow analysis and require a `PQ` load to be properly initialized. Use the Dome on-line help to learn how to connect `ThlCoi` dynamic loads.

- To simulate a generic energy storage device use the model `Storage3`, which regulates the frequency of the COI. It may be necessary to vary the initial amount of stored energy `E0` and the maximum energy limit `Emax`. In particular `Emax` has to be *big enough* to avoid saturations. Use the following parameters: `Ts = 0.1`, `Hd = 0.05` and `Kdpc = 0`. The other control gains, namely `Kppc` and `Kipc` should be varied to define an adequate response of the energy storage system.

- It is important to check that there exists a stable solution for the system "after" the contingency. This can be easily verified by solving the power flow for the system without the load at bus 6 and then solving the small-signal stability analysis.

- For all exercises, set `TDS.pq2z = True`. When solving the small-signal stability analysis, set `SSSA.pq2z = True`.

- It can be convenient to set a fixed time step for the time domain integration: `TDS.fixt = True` and a reasonably small time step, e.g., `TDS.tstep = 0.1`. 50 to 100 seconds of simulated time should be sufficient to define the behaviour of the system.

- The data file models a US network. The system frequency should be set to 60 Hz, e.g., `Settings.freq = 60`.

- The data of the case study `wscc_reg.dm` of this lab activity is based on the following book:

  P. W. Pai and M. A. Sauer, *Power System Dynamics and Stability*, Prentice Hall, 1998.