Small-Signal Stability Analysis and Hopf Bifurcations

Lab 3

EEEN50100 - Stability Analysis of Nonlinear Systems

Exercises

1. Solve the continuation power flow analysis of the IEEE 14-bus system with inclusion of dynamic synchronous machines and AVRs and determine the maximum loading condition at which the system can be operated.
2. Solve the continuation power flow analysis of the IEEE 14-bus system with inclusion of dynamic synchronous machines, AVR and one PSS connected at the machine 1 and determine the maximum loading condition at which the system can be operated. Discuss the effect of the PSS comparing the results obtained for Exercise 1.
3. Determine which of the following contingencies is the most critical for the system: line 2-4 outage, line 2-5 outage and line 4-5 outage.
4. Check the solution of one contingency analysis of Exercise 3 through a time domain simulation. Discuss whether the Hopf bifurcation is super-critical of sub-critical.

Data File

Use the files `ieee14_dynamic.dm` and `ieee14_pss.dm` that can be found in the collection of data files on the module website.

Hints

- The continuation power flow analysis can be solved using the command:

  ```
  >> dome -r CPF ieee14_static.dm
  ```

  Help on available options can be obtained using the command:

  ```
  >> dome -A CPF
  ```

- Always enforce the detection of Hopf bifurcations by setting `CPF.hopf = True`.
- For all exercises, set `CPF.mu_init = 1`.
- While solving Exercises 1 and 2, set `CPF.ending = 'nose'` to obtain the complete "nose" curve. Note that one can face numerical issues depending on the corrector and predictor method used. Typically the most critical step is the corrector method. If the default corrector method does not work, try using alternative methods. The number of points required to complete the bifurcation diagram depends on the option `CPF.step`. A small `CPF.step` is numerically more stable but requires more points, so one has to set a big value for `CPF.points`.
- The results of the continuation power flow can be plotted using `domeplot` with the same options as the results of the time domain simulations. The index 0 corresponds to the continuation parameter μ.
- When solving time domain integration and small-signal stability analysis, be sure that the options `TDS.pq2z` and `SSSA.pq2z`, respectively, are set to `False`.
- The data file models a US network. The system frequency should be set to 60 Hz, e.g., `Settings.freq = 60`.