Course:
ELEC ENG 3110 Electric Power Systems
ELEC ENG 7074 Power Systems PG

(Semester 2, 2021)

Assignment 1:
Power System Steady-State Performance

(Due, by electronic submission, 23:00, Fri. 17 Sept. 2021)

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Investigation of power system steady-state performance

The objective of this assignment is to investigate the steady-state performance of the seven bus power system depicted in Figure 1. You will employ the educational version of the Power World power-flow program to conduct the required power-flow studies.

The deliverable outcome is to be a comprehensive technical engineering report detailing clearly and concisely the conduct of your investigation that clearly summarizes and discusses the key findings from your analysis and the technical conclusions that you draw from the studies. The report should address each of the matters and questions listed in the following scope of work. Credit will be given for innovative studies and analysis that either reveal other aspects of system performance or which improve the performance of the system.

It is recommended that you follow the guidelines for writing technical engineering reports produced by Monash University and which are available at the following web-site:
https://www.monash.edu/rlo/assignment-samples/engineering/eng-writing-technical-reports

With reference to the above guidelines your report is expected to convey information to other engineers about key aspects of the performance of the system and it is intended for selective reading. The latter point means that you should organize your report into sections with informative headings.

It is strongly recommend that you approach this assignment in the same way as you would as a professional engineer conducting the project for an employer or client.

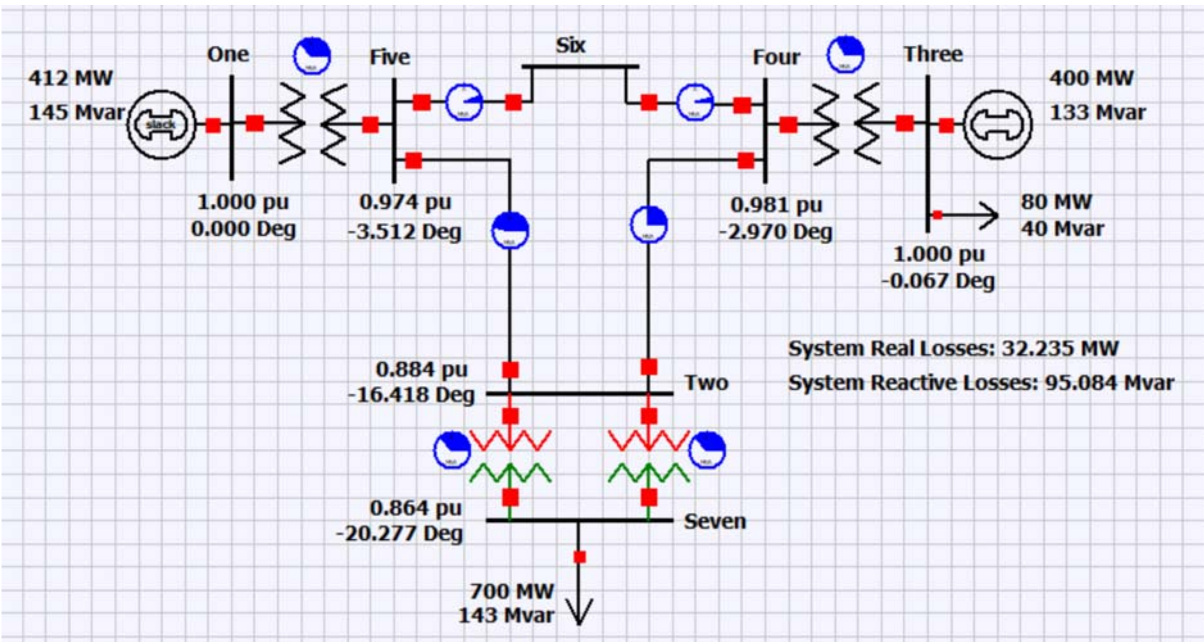

Figure 1: Base case power system model.

1 Scope of work

(a) **System model and parameters.** Clearly tabulate key parameters of the network and its components including, but not limited to,

- nominal voltage levels of the network buses;
- equipment current and/or MVA ratings;
- transformer impedances in per-unit of both system MVA base and the transformer MVA base;
- transmission line lengths, surge-impedance loads (SIL), line parameters in per-unit on the system MVA base and in per-unit of the SIL.

You will need to use the PowerWorld software and its documentation to navigate to the various forms and tables that itemize the relevant parameters. Treat this exercise as the normal process of becoming familiar with a new software package.

(b) **Analysis of base case.** For the base case scenario provided solve the power-flow and tabulate the solution including:

- the bus voltage magnitudes and angles;
- the load connected to the main load centre at bus 7;
- the output (i.e. P & Q) from the generators;
- the real and reactive power flow and losses in each transformer and transmission line;
- comparison of the transmission line power flows with their SIL.

Document the real and reactive power losses of the entire system.

Explain why the performance of the base case scenario is unsatisfactory.

(c) **Adjustment of base case.** By adjusting the transformer tap positions adjust the system 330 kV node voltages so they are between 1.0 and 1.075 pu and the main load bus voltage is in the range from 1.02 to 1.05 pu.

Explain the strategy that you use to adjust transformer tap positions.

Explain why it is desirable for the tap-positions of the two transformers between nodes 2 and 7 to be the same.

Record the system node voltages, transformer-tap positions and system losses before and after tap-adjustment.

(d) **Effect of contingencies.** The performance of the system following the outage of a transmission element is very important when assessing the secure operating limits of the system. Use the study case following the transformer-tap adjustments that you applied in the previous part as the starting system for this part. Tabulate the system voltages that result from each of the following contingencies. (Note, these contingencies are not applied cumulatively. They are each applied to your adjusted base case from (c)).

(i) Transmission line from bus 5 to 2 disconnected.

(ii) Transmission line from bus 4 to 2 disconnected.

(iii) Transmission line from bus 5 to 6 disconnected.

(iv) Transformer #2 from bus 2 to 7 disconnected.

Comment on the results from each of these contingency studies. Which of these contingencies do you consider to be the worst and why? Is the performance of the system adequate in response to any of the contingencies?

(e) **Voltage control and stability with SVC.** A potential solution for the inadequate performance of the base case following some of the above contingencies is to install a Static Var Compensator (SVC) at bus 2. A SVC can be represented, for analytical purposes, by a generator with zero power output and with reactive power limits set appropriately. Thus, to determine the required SVC capacity connect a synchronous generator to bus 2 with P = 0 and set the minimum and maximum reactive power limits to a very large value (e.g. 9.999×10^3 MVAr).

Use the study case following the transformer-tap adjustments that you applied in part (c) as the starting point for your analysis in this part.

Determine the SVC lagging reactive-power capacity that would be required to achieve a bus 2 voltage of 1.05 pu following the worst contingency.

Determine the SVC leading reactive-power capacity. Explain the basis for your determination.

(f) **Increase in SVC capacity due to increase in load.** Suppose that the main load is increased by 200 MW from 700 MW to 900 MW at the same power factor as the base case. The output of generator #3 is increased by 200 MW from 400 MW to 600 MW.

With the SVC capacity determined in the previous part can the system survive the worst line-outage contingency following the load increase? If so are the post-disturbance voltages within limits. Are the lines and transformers operating within their limits?

If necessary determine the increase in SVC capacity that is required to ensure secure supply of the 900 MW load.

2 Factors considered in assessment

This assignment is structured as an engineering investigation and the assignment report will be assessed in that context.

It is strongly recommend that you approach this assignment in the same way as you would as a professional engineer conducting the project for an employer or client.

Thus assessment will consider:

(a) Completion of the scope of work.

(b) Report organization, brevity and clarity.

(c) Clarity and sophistication in explaining the engineering significance of the findings.

(d) Accurate, relevant and clear application of power system analysis principles to the scope of work.

(e) Accuracy and correctness of results.

(f) Skill in application of the Power World power-flow program.

Students sometimes ask how long should the report be. My answer is that is a question you must decide for yourself based on what you consider to be an appropriate level of analysis and discussion required to clearly and concisely communicate your findings from your investigation to the reader. I doubt that you could achieve this objective in less than 10 pages and I doubt that you would require more than 30 pages.