Academic year 2019-2020

Group work of course ELEC0029 - Part 1

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Data file: lf_EM.dat

The following generators participate in primary frequency control: G1, G2, G3, E1 and E2, all with a frequency droop σ= 0.05.

Question 1

Adjust ARTERE parameters to simulate primary frequency control. Using the primary frequency relations derived in course ELEC0014, compute the new powers produced by generators G1, G2, …, G6 tripping of the tie-line B310-B311

- tripping of the tie-line B306-B313
- tripping of generator G5
- tripping of generator G3
- tripping of generator G6
- tripping of both tie-lines (B306-B313 and B310-B311).

In each case, compare your values with those displayed by ARTERE. Try to *approach the latter as much as possible. Explain the origin of the remaining differences.*

Question 2

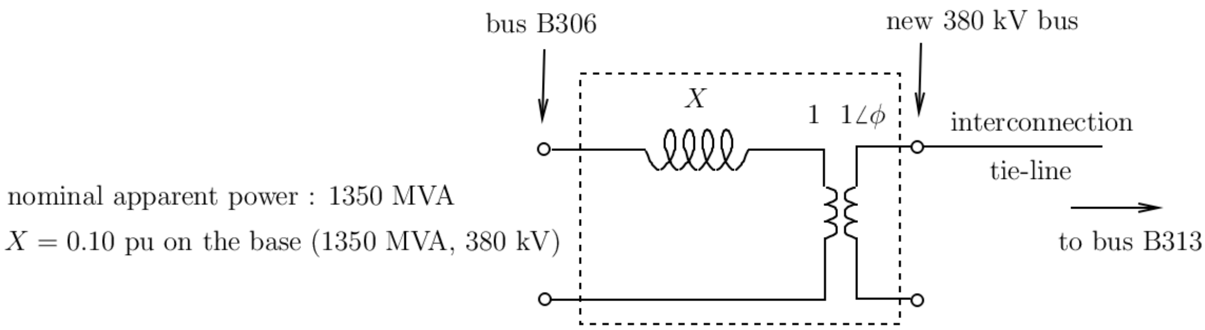
Without changing the electrical state of the system, make bus E1 the *new slack bus* of the system. Explain how you did it, and show that the state is indeed unchanged.

Adjust ARTERE parameters to simulate primary frequency control. Check that the internal system is N-1 secure with respect to the incidents enumerated in the `incid.txt` file.

Simulate a power transfer in which the generator at bus E1 increases its production by 2100 MW, while the load at bus E2 increases by 2100 MW and 0 Mvar.

With ARTERE parameters adjusted to simulate primary frequency control, perform an N-1 security analysis at the new operating point with this E1-E2 transfer, and show that the internal system is not N-1 secure any longer. Explain the cause of the limit violations.

To protect the internal system against such external power transfers, a phase shifting transformer is installed in series with the B306-B313 tie-line, on the B306 side, as shown in the figure below. The figure also gives the model and the parameters of this transformer, to be added in the data file.



Assuming that the phase angle ϕ can be adjusted in steps of 1 degree, determine the pre-disturbance value of ϕ such that the internal system is now N-1 secure when subjected to the above E1-E2 transfer.

Compare the pre-contingency operating points with the E1-E2 power transfer :

- before adding the phase shifting transformer
- after adding the phase shifting transformer but with no phase shift (ϕ =0)
- after adding and adjusting the phase shifting transformer to the above computed value.

Question 3

The objective of this exercise is to bring the voltage at bus B301 to 395.2 kV by adjusting the voltages of generators G1 and/or G2.

- Show that this is not possible by adjusting G1 alone. Explain why;
- show that this is possible by adjusting the voltages of both G1 and G2. Explain why;
- determine the two generator voltages V_{G1} and V_{G2} in order to reach the desired voltage at bus B301 while minimizing the total "control effort" :
$$\left|V_{G1} - V_{G1}^{bc}\right| + \left|V_{G2} - V_{G2}^{bc}\right|$$
where V_{G1}^{bc} and V_{G2}^{bc} are the base case values specified in the lf_EM.dat data file.

Question 4

The maximum power transfer from generator to load and the PV curve were defined in course ELEC0014 (Chapter 4). The objective of this exercise is to use successive power flow computations to determine PV curves in the 28-bus system.

Consider a load increase in a zone including buses B101, B102, B103 and B106. As regards active powers, the various loads are increased proportionally to their base case value (lf_EM.dat data file), i.e. each load keeps consuming the same fraction of the sum of the four loads. This load increase is covered by generator E2. As regards reactive powers, the power factor of each load keeps it base case value.

Take the line L306-304 out of service[1].

Determine the upper parts of a few PV curves, where P is the total active power *increase* in the zone (with respect to the base case) and V the voltage at some bus. Select the buses that you consider of interest and comment on the corresponding curve.

Comment in detail on the changes taking place as the load is increased and when its maximum is reached. Indicate the accuracy with which the maximum load increase is determined.

Comments are as important as the numerical results !

Send your report in PDF format to t.vancutsem@uliege.be by April 29, 2020 at the latest.

Questions 2 and 3: e-mail a copy of your final ARTERE data files to t.vancutsem@ulg.ac.be

[1] Do not forget to put the line back into service at the end of the exercise !