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Voltage Stability

DEE-24106 – Electric Power Systems

Objective:

The objective of the assignment is to understand the principles of power system voltage stability. In addition, the basic skills to utilize PSCAD for power system analysis are achieved.

How the assignment is realized:

The assignment is to be done in the same groups (consisting of two or three persons) as the first assignment. The PSCAD software, which is used for the simulation exercises of this assignment, is installed to the PC classroom SF213. All participants (signed up in POP) will get access to the computer class automatically. However, in order to use PSCAD you will have to first register at https://mycentre.hvdc.ca/register. You can also install the free version of PSCAD to your own computer (guide: http://www.youtube.com/watch?v=z7hs66I13_E&NR=1&feature=endscreen). If you have problems related to the assignment contact Nida Riaz (nida.riaz@tuni.fi). Required project files can be downloaded from the course page at Moodle. The reports files should be either Microsoft word or PDF and should be return on Moodle page. Name your report according to your group.

Deadline for returning the report: Thursday 16th of February, 2019

1. Generator initialization

Open the PSCAD file Assignment2_BaseCase.pscx which was attached to the ZIP package that you downloaded from the course page in Moodle. This file contains a PSCAD model of the system which is depicted in Fig. 1. Use PSCAD On-Line Help to familiarize yourself with the start-up and initialization of the synchronous generator component. The Help file of each component can be found by right-clicking the desired component and selecting Help. From the synchronous generator online help, choose the "Start-up and Initialization". Answer the following questions on the operation of the generator component:

1.1. How does the logical variable "S2M" influence the generator operation?
1.2. How does the logical variable "L2N" influence the generator operation?
1.3. Why are these variables necessary to the simulation?

Don't make changes to the "Sample/Hold"-component connected to the "Ef0" output of the generator or to the Timer components used for generating the signals "S2M" and "L2N".

2. Load models and voltage stability

In Fig. 1 the generator G is feeding the load K (nominal power varied between 700 – 850 MVA, power factor cos φ = 0.95) via transformer T2 and transmission line L. Examine the effect of load characteristics on the stability of the system by changing the nominal power of the load model as described in table 2.1. Simulate all the 3 loading situations using two different load types which are given below (i.e. simulate 6 cases in total). Note that the values for the load model in the given PSCAD model are entered as power per phase values. You can obtain more information concerning the load model by right clicking the load component with your mouse and then choosing "help". An excel file named Assignment_2 is attached to the ZIP

package that you downloaded from the POP. Fill the requested values to the ready-made excel tables based on your simulations. Use the values that you get at the end of your simulation (note that you may have to use the zooming options on the graphs which can be accessed by right-clicking your mouse on the graphs). Round your answers to a precision of three decimal places (e.g. 0.901). It is advisable to also observe the active and reactive power graphs for your own understanding. In this assignment you may assume the system to be stable whenever the voltage stabilises to a value larger than 0.9 p.u at the end of the simulation (i.e. approximately at time 15s in this exercise).

- Simulate the three cases using constant impedance load model (i.e. use value 2 for the volt indexes dP/dV & dQ/dV). Fill the requested values on the excel tables. Use value 0 for “Freq Index” parameters as this aspect is not studied in this assignment.
- Simulate the three cases using constant current load model (i.e. use value 1 for the volt indexes dP/dV & dQ/dV). Fill the requested values on the excel tables.

Answer the following questions based on your simulations

2.1. Which of the two load types caused the voltage to drop more? Why?
2.2. The voltages in these studies stabilise to certain values even though they may be below 0.9.

Table 2.1. Three phase power ratings of the load K

S [MVA]	P [MW]	Q [MVar]
700	*665*	*219*
750	*713*	*234*
850	*808*	*265*

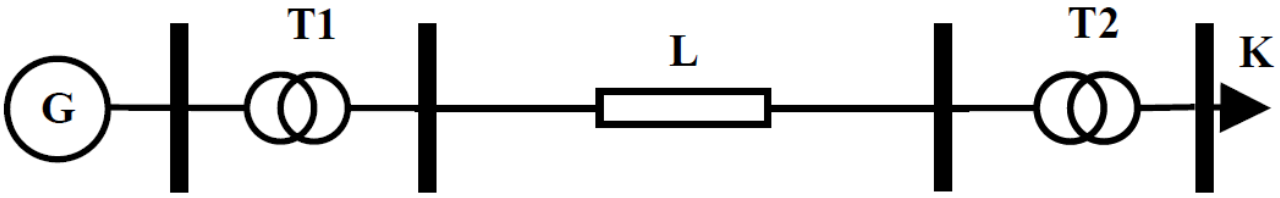

Fig. 1. The studied system in section 2

3. The effect of On-Load Tap-Changer (OLTC) on voltage stability

3.1. Let us add an OLTC to the transformer T2 as shown in Fig. 2 by opening the file Assignment2_OLTC.pscx from the zip file that you downloaded from POP. Note that the tap changer model is ready-made in the PSCAD file and should not be modified.

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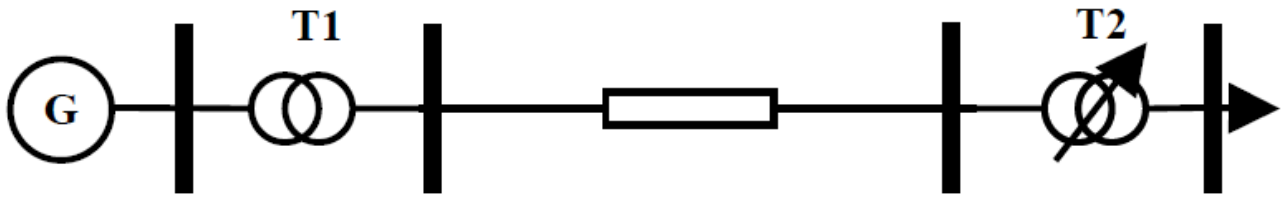

Fig. 2. The studied system in section 3

Study the voltage stability of the system in three different loading scenarios (load is varied between 700 – 800 MVA, power factor cos φ = 0.95). The studied three loading situations are described in Table 3.1 (note that the power values are given as three phase values). Model the load first as a constant impedance load (set the volt indexes dP/dV & dQ/dV to 2) and then as a constant current load (set the volt indexes dP/dV & dQ/dV to 1). Fill the voltage values at the end of the simulation to the ready-made excel tables.

Table 3.1. Three phase nominal power ratings for the load

S [MVA]	P [MW]	Q [MVar]
700	*665*	*219*
775	*736*	*242*
850	*808*	*265*

Answer the following questions based on your simulations

3.2. Why is the voltage stability limit (i.e. the power transfer level which causes the voltages to drop below 0.9 p.u.) now different in comparison with exercise 2 where OLTC was not included especially in the case of constant impedance load? If you have difficulties in answering to this question, you may find the following thoughts helpful:

- The tap changer tries to increase the secondary side voltage of the transformer. How does this affect the load current and power consumption of the load?
- How does this affect the current on the transmission line? Observe the current, voltages and the reactive power consumption of the transmission grid.

3.3. Describe how voltage instability occurs with the help of your simulation results. Add graphs from one of the simulation cases where voltage stability is lost and explain the incidents that lead to voltage instability using the graphs of your choice. You can copy graphs from PSCAD by right clicking a graph pane from the upper edge and choosing “Copy as Meta-File”. After this, simply paste the copied graph to your report.