Assignment: Modelling and Simulation, Steady-state Analysis

Rationale

The idea of this practical assignment is to enhance the student experience by including practical aspects of modelling and simulation of the electrical power system through software DIgSILENT PowerFactory. Power system analysis software is a reality in the day a day job of power system engineers; as a consequence, students with that set of skill will have a competitive advantage in the job market.

Intended Learning Outcomes assessed by this assignment

- Advanced knowledge on modelling of electrical power systems.
- Knowledge of the steady-state analysis (power flow) of three-phase, symmetrical, and balanced power systems.

Conditions

- This assignment must be approved in order to take a grade in the subject.
- The software DIgSILENT PowerFactory must be used as the simulating software.

Resources

Several Learning tutorials are provided in the Learning environment (DIgSILENT PowerFactory Area) in order to assist you in creating the power system models, performing power flow simulation and exporting a project. Also, installation of PowerFactory and all required data is provided.

Submission

The student must submit files using CANVAS learning environment. The student must take into considerations the following protocol:

1. Written report (.doc file format): Computer_Assignment_report_SURNAME.doc.
2. Project_Files (.pfd file format: PowerFactory format): Computer_Assignment_software_SURNAME.pfd
3. Other_files (original file format): Any other file used for calculation or supporting them supporting documents (e.g. MS Excel files, Matlab, etc.)

All the files must be included in a folder named SURNAME_NAME.zip (.zip file format).

The student must submit only the zipped file.

The student must use the MS Word template designed for this assignment: SURNAME_NAME_Template.doc.

Note that submission with missing files or numerical results without any meaningful discussion will not be processed.

Deadline for submission: 25/10/2020 at 23:59

Creating a Power System and Voltage Dependence of the Loads

This exercise is designed to *create a power system* and *analyse the effect of the voltage dependence of the loads in the system performance.*

The idea of this exercise is to make the student aware of some 'realistic situations' related to relatively size power system. However, the test system used in the exercise extremely small system is nothing compared with a real interconnected system like ENTSO-E: https://www.entsoe.eu/data/map/

The system under consideration is a generic 12-bus system designed for wind integration studies, and the single line diagram is shown below.

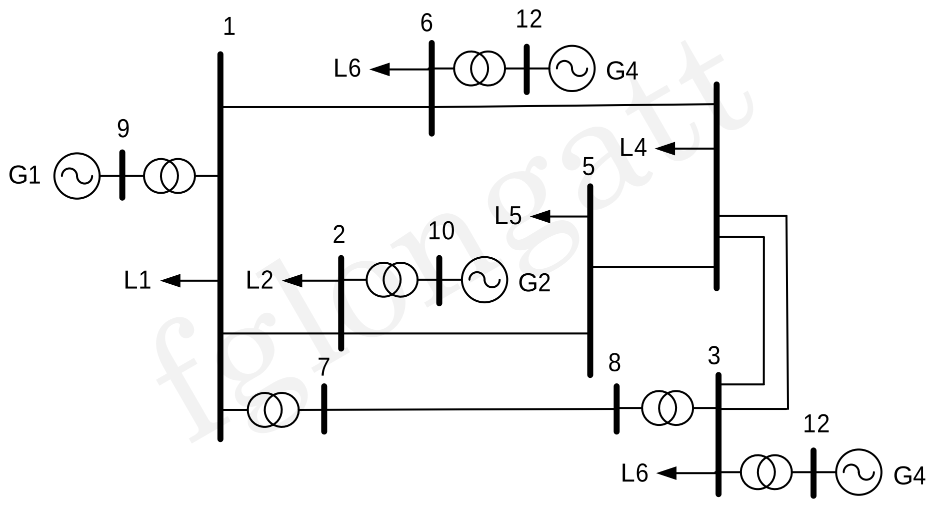


Figure 1. Generic 12-Bus Test System for Wind Power Integration Studies [1].

The small 12-bus system as originally introduced in the paper [1].

[1] A. Adamczyk, M. Altin, Ö. Göksu, R. Teodorescu and F. Iov, "Generic 12-bus test system for wind power integration studies," *2013 15th European Conference on Power Electronics and Applications (EPE)*, Lille, 2013, pp. 1-6, doi: 10.1109/EPE.2013.6634758.

Link to download the paper: https://ieeexplore.ieee.org/document/6634758

TASKS:

(1.1) Calculate the real unit values (evidence: .xls file)

Create a table with the appropriately data and calculated values using Microsoft Excel.

(1.2) Creating the power system model (evidence: .pfd file)

Using the appropriate steps defined in the practical session, create the model of the Generic 12-Bus Test System for Wind Power Integration Studies in DIgSILENT PowerFactory.

(1.3) Validating the load flow solution (evidence: .xls file)

Calculate the power flow of the implemented system (1.1) and compare the numerical results obtained with the results presented in Reference [1].

Calculate the Absolute Error and the Relative Error in bus voltages magnitudes (|*V*|, pu) and angles (θ, degree)

Absolute Error = (*Value[1]* - *PF Value*)

Relative Error = *Absolute Error* / *Value[1]*

where:

Value[1]: It is the value shown in Figure 2 Reference [1]

PF Value: It is the result obtained from DIgSILENT PowerFactory Simulation

(1.4) Voltage dependence of the loads (evidence: .xls file)

Add a type model to each load in the DIgSILENT PowerFactory model, the type load (TypLod) must be set for the following cases:

- CASE I: Constant Impedance model
- CASE II: Constant Current model
- CASE III: Constant Power model

Compare the *total active power losses* (P_{loss}) between cases and conclude about the effect of the voltage dependence model.

Hint: Student must read the Technical Reference inside PowerFactory of the General load (*TypLod*). Specifically, section 2.3 titled "*Voltage dependency*".
The voltage dependency of loads in PowerFactory is modelled using three polynomial terms.

$$P = P_0\left[aP\left(\frac{|V|}{V_0}\right)^{e\_aP} + bP\left(\frac{|V|}{V_0}\right)^{e\_bP} + (1 - aP - bP)\left(\frac{|V|}{V_0}\right)^{e\_cP}\right]$$

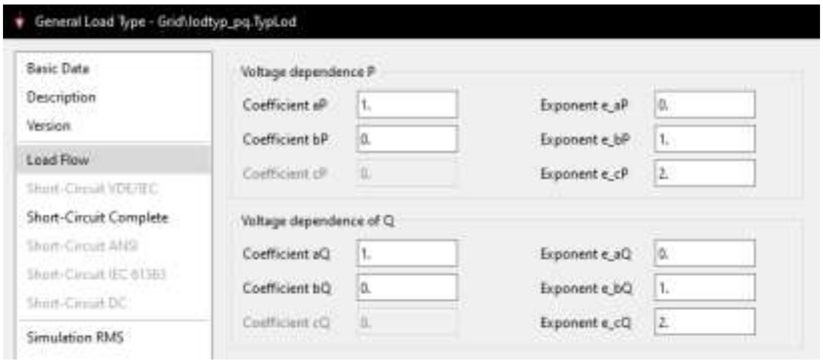
$$Q = Q_0\left[aQ\left(\frac{|V|}{V_0}\right)^{e\_aQ} + bQ\left(\frac{|V|}{V_0}\right)^{e\_bQ} + (1 - aQ - bQ)\left(\frac{|V|}{V_0}\right)^{e\_cQ}\right]$$

Changing the load type to constant *impedance, Current or Power* can be accomplished by modifying the exponential coefficients of the load according to Table A.

Table A. Selection of exponent value for different load model behaviour

Load model type	*Exponential coefficient*
Constant power	0
Constant current	1
Constant impedance	2

An illustrative example of the settings of voltage dependence in *TypLod* is shown below.



Final comments

Prof F. Gonzalez-Longatt is available for any question or doubt, and please do not hesitate to send an email requesting more information or special support.