TU Wien

Institute for Energy Systems and Electric Drives

370.023 Energieversorgung, Vertiefung

1. Objectives

▪ Familiarisation with the DIgSILENT Power Factory software package

▪ Understanding the voltage regulation issues with distributed generation

▪ Familiarise with various strategies to regulate the voltage of the distribution feeder

2. Equipment and software

DIgsILENT PowerFactory 2023 (x64). You can download the installation file in TUWEL. You will be assigned an individual license code. The education version of PowerFactory can only be run on a Windows operating system.

Please check if your PC meets the system requirements.

There will be a group division of 3 people per group, please think about a possible division in advance. For MAC users, 3 mini-PCs are available at the institute.

3. Prerequisites

Revise lecture Netzsimulation – Theorie **Fachvertiefung – Energiesysteme.**

4. DIgSILENT Power Factory Software Package

DIgSILENT Power Factory is the leading high-end power system analysis tool for applications in generation, transmission, distribution and industrial systems. It is integrating all required functions, easy to use, fully Windows compatible and combines reliable and flexible system modelling capabilities with state-of-the-art algorithms and a unique database concept. Besides the stand-alone functionality, the Power Factory engine integrates smoothly into any GIS, DMS or EMS supporting open system standards. The DIgSILENT offers following functionalities.

5. Network Setup

Download “AP_Assignment.pfd” and save it in your computer. Open the DIgSILENT Power Factory (PF) and then go to: “File>>Import>>Data (*.pfd,*.dz,*.dle)”. Then select the “AP_Assignment.pfd” file from the place where you saved it in the computer and then click “Open”. Then activate the project: “File>>Activate Project” and select the project “AP_Assignment” and press “OK”. A schematic of the network model is shown in Figure 1

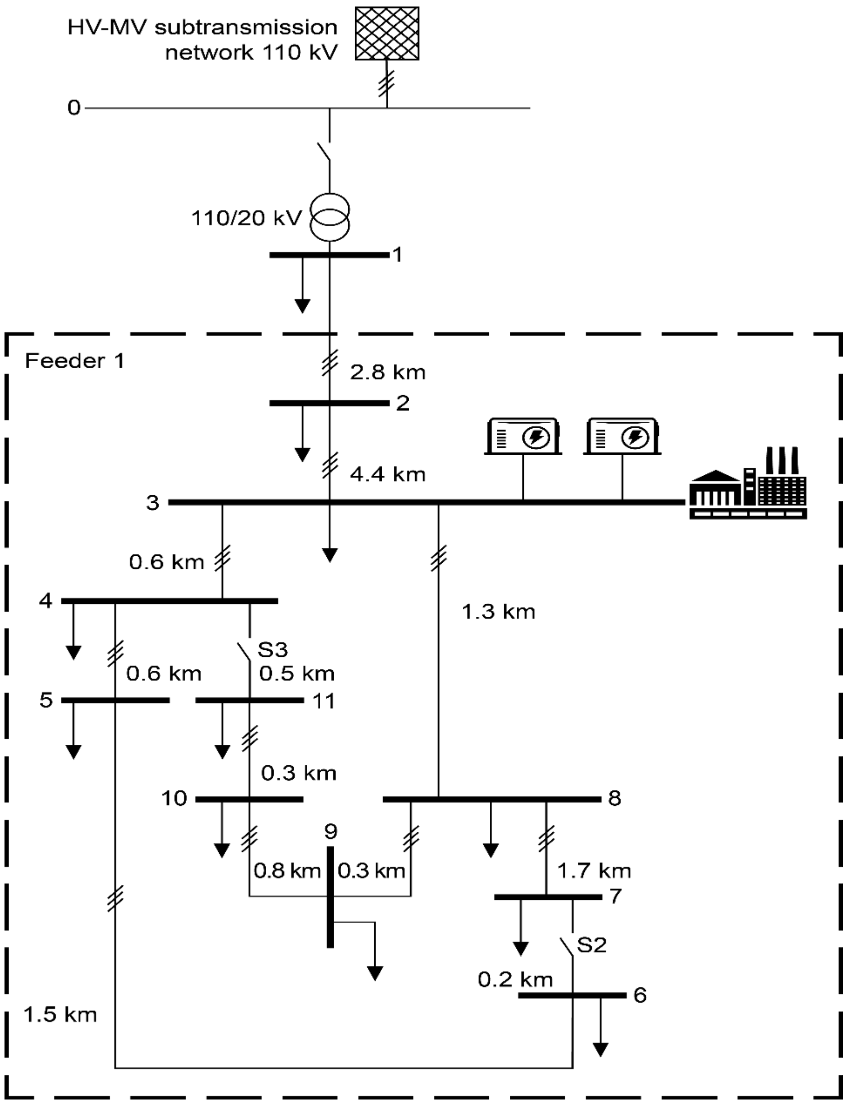

Figure 1 Part of the European European MV distribution network benchmark

Topology of European MV distribution network benchmark

In our simulation we adpted part of the Feeder 1 of European MV distribution network benchmark European MV distribution feeders are three-phase and either of meshed or radial structure, with the latter dominating rural installations and a industria factory. The benchmark allows flexibility to model both meshed and radial structures. Each feeder includes numerous laterals at which MV/LV transformers would be connected. The nominal voltage is 20kV. The system frequency is 50 Hz.

Symmetry: Efforts are typically made to balance the various low voltage laterals along the MV lines, but some unbalances are still typically experienced in practice. Unbalance is no explicitly included in the European benchmark, but it can be introduced if desired.

Line types: Overhead lines are used with bare conductors made of aluminum with or without steel reinforcement, i.e. A1 or A1/S1A. Underground cables are XLPE with round, stranded aluminum conductors and copper tape shields.

Grounding: The grounding of the MV network largely depends on regional preferences.

European networks are typically ungrounded or impedance-grounded.

Network Data

Line segment	Node from	Node to	Conductor ID	R'_{ph}	X'_{ph}	B'_{ph}	R'_0	X'_0	B'_0	l	Installation
				[Ω/km]	[Ω/km]	[μS/km]	[Ω/km]	[Ω/km]	[μS/km]	[km]	
1	1	2	2	0.501	0.716	47.493	0.817	1.598	47.493	2.82	underground
2	2	3	2	0.501	0.716	47.493	0.817	1.598	47.493	4.42	underground
3	3	4	2	0.501	0.716	47.493	0.817	1.598	47.493	0.61	underground
4	4	5	2	0.501	0.716	47.493	0.817	1.598	47.493	0.56	underground
5	5	6	2	0.501	0.716	47.493	0.817	1.598	47.493	1.54	underground
6	6	7	2	0.501	0.716	47.493	0.817	1.598	47.493	0.24	underground
7	7	8	2	0.501	0.716	47.493	0.817	1.598	47.493	1.67	underground
8	8	9	2	0.501	0.716	47.493	0.817	1.598	47.493	0.32	underground
9	9	10	2	0.501	0.716	47.493	0.817	1.598	47.493	0.77	underground
10	10	11	2	0.501	0.716	47.493	0.817	1.598	47.493	0.33	underground
11	11	4	2	0.501	0.716	47.493	0.817	1.598	47.493	0.49	underground
12	3	8	2	0.501	0.716	47.493	0.817	1.598	47.493	1.30	underground
13	12	13	1	0.510	0.366	3.172	0.658	1.611	1.280	4.89	overhead
14	13	14	1	0.510	0.366	3.172	0.658	1.611	1.280	2.99	overhead
15	14	8	1	0.510	0.366	3.172	0.658	1.611	1.280	2.00	overhead

Assignment Tasks

Assume that you are a Power System Planning Engineer working for a Power Utility Company. The Chief Engineer in the power system planning department asked you to conduct a system study for The Medium Voltage system in Figure 1. The following analysis needs to be done and recorded:

1. First determine the steady-state bus voltage magnitudes, voltage angles, active and reactive power of each component terminal and external grid after running a load flow calculation. Record these values in a Table. Generate Plot for Maximum voltage of all terminals Minimum voltage of all terminals.

Hint: Power Factory can generate Grid summary with all parameters, check it accordingly.

2. Active (P) and Reactive (Q) Power sensitivity analysis:

Keeping all other variables constant, added a 3 MW load (Factory) to bus 3 according to Figure 1. Then, change the active power P of load on Bus_03 & Bus _04. Starting from their initial values, separately for each bus increase the value of P in steps of 4.5 KW till you reach a value more than 45 KW from their initial value. Give comments about overall system at this point. Record values in a Table.

Hint: use output report window, you will find details of each control change you perform.

Next, **Switch OFF Diesel generator 2** and run load flow calculation. Give a comment on the overall system behaviour.

Switch On Diesel Generator 2. Then, switch **OFF diesel generator 1** and start increasing the value of P in Bus 8 and Bus 7 from their initial values separately for each bus at each step of 5 KW till you reach 30 KW note the magnitude and angle in Bus 8 and Bus 7. Each step need run load flow calculation, give comments about overall system behaviour at this point. Record values in a Table. **Draw graph showing active power at each step for both buses.**

Hint: you can use excel file and generate graphs there is much easier and faster

3. Now, your chief engineer asks to find a solution to reduce carbon footprint from diesel generator in Bus 3 by renewable energy generators such as PVs and a battery storage system as assumption to guarantee 24/7 supply of energy to the factory. How much Active Power from each PV should be injected to supply our network and keep a balanced network. You should save every step in your PF project file.

4. Connect two wind Turbine generator to bus system Bus 3 and bus 7 with active power 1.5 MW and 0.5 reactive power .Then, record each bus voltages, also P and Q in all buses in a Table. is there any impact on the overall MV system connection point.? Generate voltage profile for both buses with PF tools and added to your report

Assuming that you will notice a voltages violation on the connection points such as Bus-4 & Bus 7 voltages If such issues exist, what your solution to propose to fix (do some research online)?

Hint: Always bus voltages must be maintained between 0.95 – 1.10 pu.

Notes:

This Assignment is based on European MV voltage Benchmark, and this system is originally designed as a 50 Hz system (Since it is a EU based Test System). Therefore, for every NEW Element you include in the model, such as Wind Generator, PV etc. you should use 50 Hz as the system frequency

How to Submit the Assignment?

Each group should present all the results obtained for each Task in a report with sufficient discussion for each assignment Submit your MS Word or PDF file with your DIgSILENT file through TUWEL Assignment Submission System following the directions given in the course before the deadline.

Assignments must be submitted before 31 May 2024.