Power Factory Assignment TSE2220

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2 INTRODUCTION

This assignment accounts for 10 % of the total grade of the subject TSE2220. You will use the simulation software DIGSILENT PowerFactory as the simulation tool for this assignment. The first part of the assignment is to create an 11 kV distribution network according to the given network data. The second part is to carry out various calculations and analysis of the network. Both parts will be considered during grading.
You need to hand in two documents in Canvas:

1. A pfd file of your power system (.pfd is the PowerFactory file format, NOT pdf).
2. A document that provides the simulation results for the different tasks.

3 TASK 1: NETWORK CONFIGURATION (25 %)

NETWORK TOPOLOGY AND NAMES

Figure 1 shows the topology of the grid. The network consists of a power transformer 132/11 kV (T1) and 3 distribution transformers 11/0.230 kV which supply power to residences. Please use the same naming convention as in the figure.

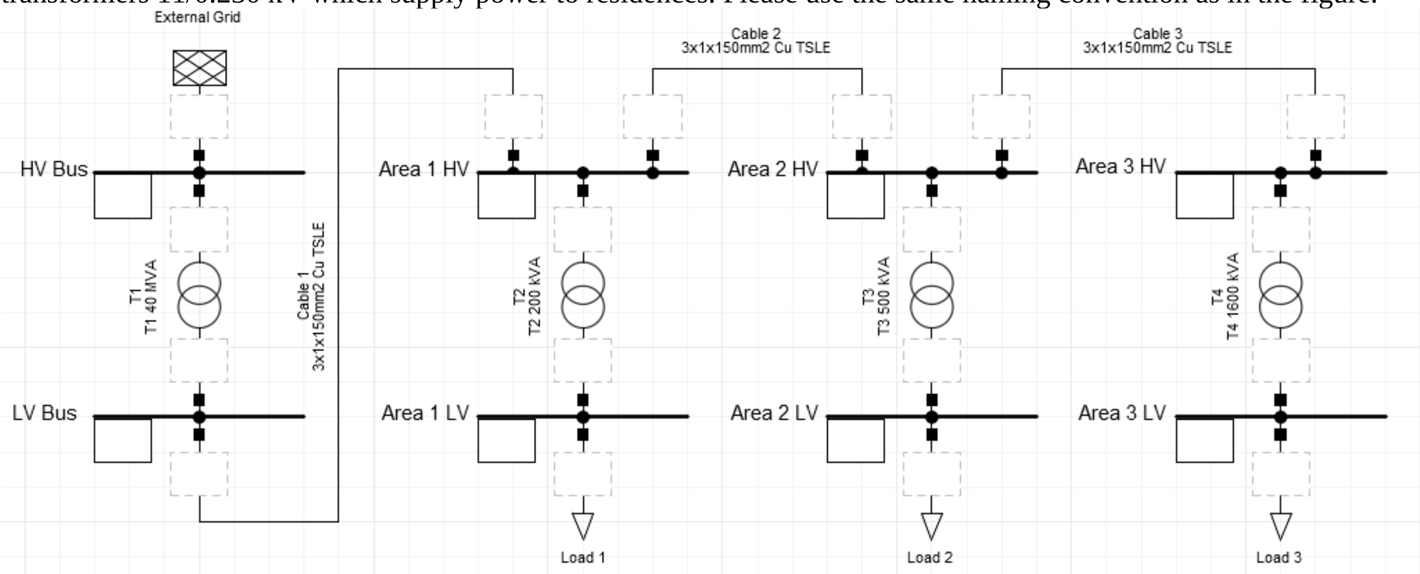

Figure 1 The single line diagram of the 11 kV & 0.23 kV distribution network.

TRANSFORMER DATA

Table 1 shows the values that you need to add to you transformers on Type → Base Data. All other data remains unchanged.

Table 1 Transformer data

Name	From bus	To bus	V_{HV} [kV]	V_{LV} [kV]	Rated power	Short-Circuit voltage u_k
T1	HV Bus	LV Bus	132	11	40 MVA	3 %
T2	Area 1 HV	Area 1 LV	11	0.23	400 kVA	6 %
T3	Area 2 HV	Area 2 LV	11	0.23	700 kVA	6 %
T4	Area 3 HV	Area 3 LV	11	0.23	2.0 MVA	6 %

EXTERNAL GRID

In the External Grid component, go to the “Short-Circuit Complete” tab, as shown in Figure 2. Change max short circuit fault level S''_{k_max} to 100 MVA and min short circuit fault level S''_{k_min} to 60 MVA.

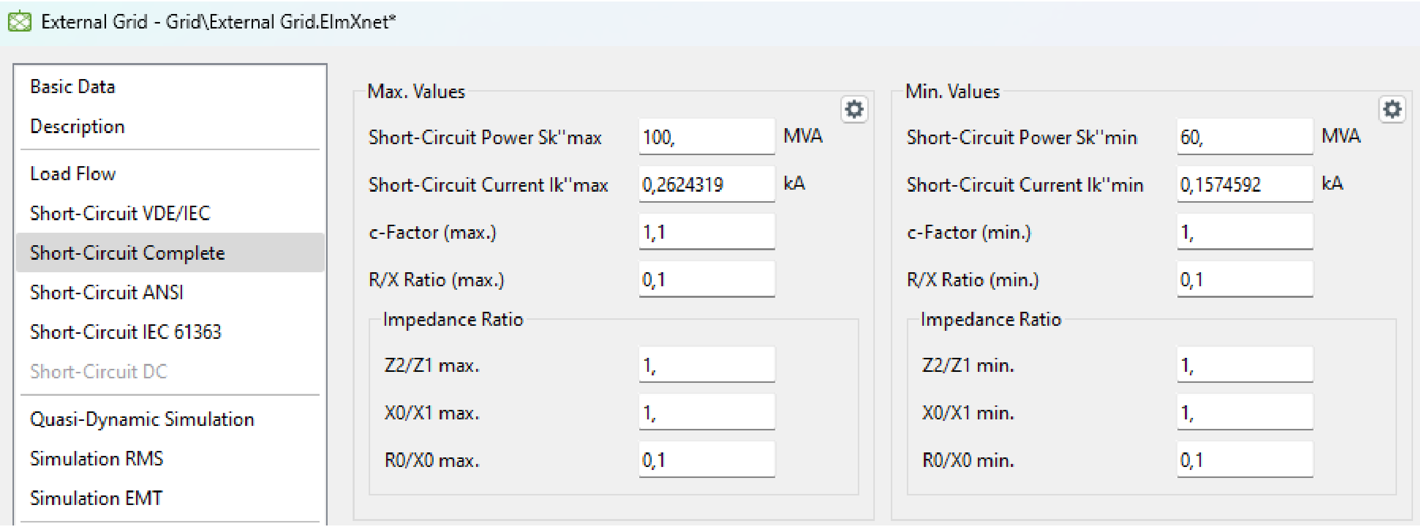

Figure 2 Inserting values for the External Grid Component.

Load Data

Fill in the active power and power factor for the different loads in the system. The data for the loads are given in the table below.

Table 2 Loading for the three substations in active power P and power factor.

Load	Load [kW]	Power Factor
Load Area 1	150	0.96 (lagging)
Load Area 2	400	0.96 (lagging)
Load Area 3	1500	0.96 (lagging)

Cables

Insert cable length, resistance, reactance, and capacitance in the PowerFactory model according to data from Table 3. See Appendix 1 for data of the Draka cable. Use flat cable configuration when looking up the values.
Note: To insert the capacitance value of the cable, go to the “Load Flow” tab in the cable type. Then click on the gear symbol to change the input data from Susceptance B’ to Capacitance C’, see Figure 2.

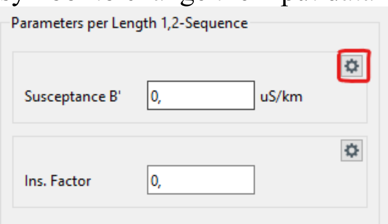

Figure 3 How to insert capacitance per km in PowerFactory.

Table 3: Cable data

Cable Name	Between buses	Cable brand /Type	Cable properties per km			Length
			R [Ω/km]	X [Ω/km]	C [µF/km]	
Cable 1	LV Bus and Area 1 HV	TSLI 12/20 (24) kV Cu 3x1x150	See Appendix 1			200 m
Cable 2	Area 1 HV and Area 2 HV	TSLI 12/20 (24) kV Cu 3x1x150				2000 m
Cable 3	Area 2 HV and Area 3 HV	TSLI 12/20 (24) kV Cu 3x1x150				1000 m

EXPORT YOUR MODEL

At this point, after inserting all grid components and data, export your model from PowerFactory to a .pfd (Power Factory Data file). To do this, go to File/Export/Data (*.pfd;*.dz)…. Choose the model you just made and clock OK. PowerFactory will ask you to deactivate the project. Click Yes. This file must be a part of your submission in Canvas.

4 TASK 2 – LOAD FLOW SIMULATION (35 %)

In this task, you will execute Power Flow calculations to obtain load voltages, grid losses, and transformer loading factors.

a) Do a load flow in PowerFactory. Answer this task with a picture of the grid with the displayed results.
b) Assume you want to add 200 kW to the system, and you can add this load to either Area 1, 2, or 3 (on the LV side). Where would you have placed such a load? Elaborate on your answer. Remember to remove this additional load when you are done with this task.
c) Change the length of Cable 1 to 16000 m. Use this until further notice. Run a load flow simulation and show the results as in task a). Does the power system still have a satisfactory network? Give reasons for your answer considering voltage levels of the busbars.
d) How much active power losses are there in this network during the simulation of problem 1 c?

5 TASK 3 – SHORT-CIRCUIT ANALYSIS (40 %)

When performing short-circuit calculations, use the calculation method “Complete”. The calculation method is configured before executing a short circuit calculation, as shown in Figure 3.

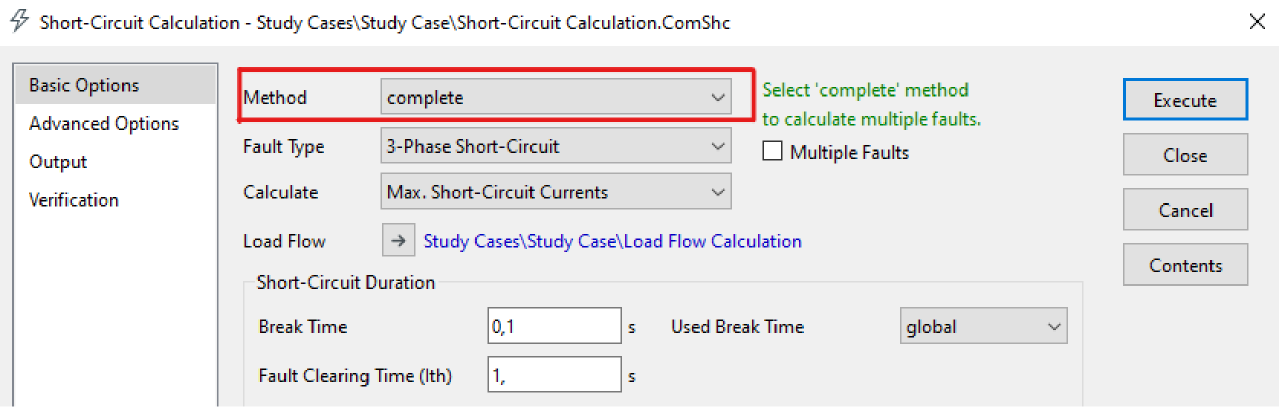

Figure 4 Changing the calculation method to "Complete" in PowerFactory.

Change the length of Cable 1 back to 200 m.

a) For each bus calculate **maximum three-phase short circuit**, and **minimum three-phase short circuit** values. Take a picture of the screen as the answer for this task.
b) Briefly explain why the short circuit values are different between the different bus bars.
c) By hand, calculate the short circuit powers of the network using the admittance method. Fill in the results in a table like Table 5. Please provide your calculation steps in the report.

Maximum and minimum short-circuit fault level in the external grid is changed to 1000 MVA and 600 MVA, respectively. Keep these values for the rest of the assignment.

d) What will the short circuit results be at the distribution transformers now? (computer simulation only)
e) Compare results from task a) and task d). Give a brief explanation of why the results are different.

The internal inductance (u_k) is now increased in transformer T1 to 13 %.

f) What are the short circuit results now?
g) Why is the answer different from task a)? Explain briefly.

6 APPENDIX 1:

TSLE 12/20(24)kV Cu Draka Cable :

Denne illustrasjonen er et eksempel fra dette produktutvalget, og vil nødvendigvis ikke stemme helt overens med konstruksjonen, antall ledere og farge.

Bruksområde

Enleder distribusjonskabel, tillatt utendørs i jord, luft og vann. Kabelen er aksielt og radielt vanntett og kan belastes i henhold til NEN 62.75. Ved innendørs installasjoner skal kablene males med brannhemmende maling eller legges i kanal.

Oppbygging	
Leder	Flertrådet, rund kobber i henhold til IEC 60228 klasse 2, aksielt vanntett
Indre halvledende sjikt	Ekstrudert
Isolasjon	PEX (XLPE), nom. tykkelse = 4,85mm
Ytre halvledende sjikt	Fastvulket
Aksiell vanntetthet	halvledende svellebånd
Skjerm	Glødet kobber
Radiell vanntetthet	Aluminium-PE laminat, limt til kappe
Kappe	PE, sort, UV-resistent,
Eksempel på merking	Utvendig merket typebetegnelse og dimensjon. Metermerking og produksjonsår

Alternativ typebetegnelse:	N20XC7A5E-R
Konstruksjon:	HD 620 Part 10 Seksjon K og M
Flammehemmende:	Nei
Halogenfri:	EN 60754-1 /-2
Maks. ledertemp:	90ºC
Laveste kabeltemperatur ved forlegning:	-20°C
Legges med forsiktighet:	under 0°C
Støtspenning:	125 kV

Min. bøyeradius

Ved fast montering:	10 x D
Under montering:	15 x D

CE RoHS REACH

Lederantall x areal mm²	Leder resistans Ω/km	Skjerm resistans * Ω/km	Induktans i trekant/ flat mH/km	Reaktans i trekant/ flat Ω/km	Kapasitans µF/km	Kapasitiv utladningstrøm/ fase. A/km	Kapasitiv jordslutning strøm/fase. A/km
1 x 50/16	0,387	1,15	0,43/0,73	0,14/0,23	0,17	0,6	1,9
1 x 70/16	0,268	1,15	0,41/0,70	0,13/0,22	0,19	0,7	2,1
1 x 95/25	0,193	0,727	0,39/0,67	0,11/0,21	0,21	0,8	2,4
1 x1 20/25	0,153	0,727	0,38/0,65	0,12/0,21	0,23	0,9	2,6
1 x 150/25	0,124	0,727	0,36/0,63	0,11/0,20	0,25	0,9	2,8
1 x 185/35	0,0991	0,524	0,35/0,61	0,11/0,19	0,27	1,0	3,1
1 x 240/35	0,0754	0,524	0,34/0,59	0,11/0,19	0,30	1,1	3,4
1 x 300/35	0,0601	0,524	0,32/0,57	0,10/0,18	0,33	1,2	3,7
1 x 400/35	0,0470	0,524	0,31/0,55	0,10/0,17	0,37	1,4	4,2
1 x 500/35	0,0366	0,524	0,30/0,53	0,09/0,17	0,40	1,5	4,5
1 x 630/50	0,0283	0,387	0,29/0,51	0,09/0,16	0,45	1,7	5,4

* Kabelavstand i flat forlegning = 70mm
OBS. Skjermareal/skjermresistans er summen av kobbertråder og aluminiums bånd