LELEC 2595 - Project

Context

The objective of the work is the assessment of the *power quality requirements for the connection of a potentially disturbing load* to an existing 70 kV sub-transmission grid.

The single-line diagram of the grid is given in Figure 1.

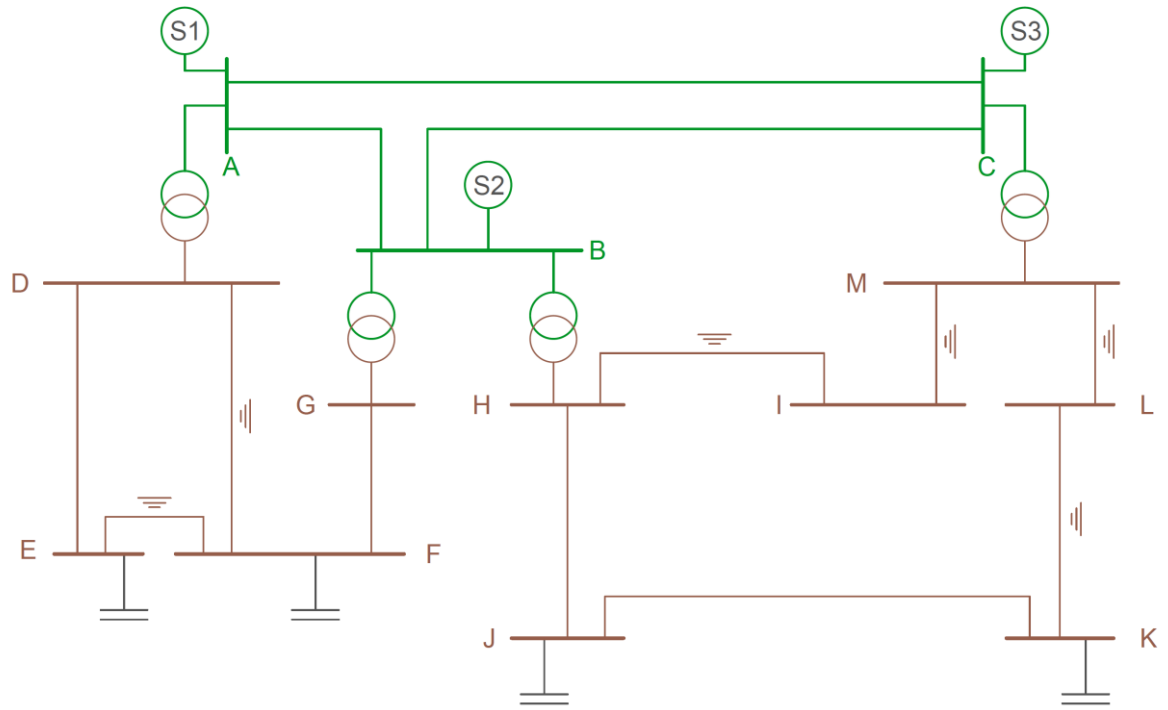

Figure 1 – Single-line diagram of the considered sub-transmission grid

The grid data are given in the following tables.

Sources

	Nominal Voltage	Three-phase fault level	X/R ratio
S1	220 kV	10 GVA	7
S2	220 kV	5 GVA	6
S3	220 kV	3,5 GVA	6

Transformers

	Voltages	Config.	Power (MVA)	R (p.u.)	L (p.u.)
A-D	220 kV / 70 kV	YgYg	100	0,004	0,16
B-G	220 kV / 70 kV	YgYg	100	0,004	0,15
B-H	220 kV / 70 kV	YgYg	220	0,002	0,20
C-M	220 kV / 70 kV	YgYg	220	0,002	0,20

Lines

	Voltage (kV)	Length (km)	R1 (Ω/km)	R0 (Ω/km)	L1 (H/km)	L0 (H/km)	C1 (F/km)	C0 (F/km)
A-B	220	60	0,012	0,38	$0,9\ 10^{-3}$	$4,1\ 10^{-3}$	$12,3\ 10^{-9}$	$7,7\ 10^{-9}$
A-C	220	80	0,012	0,38	$0,9\ 10^{-3}$	$4,1\ 10^{-3}$	$12,3\ 10^{-9}$	$7,7\ 10^{-9}$
B-C	220	50	0,012	0,38	$0,9\ 10^{-3}$	$4,1\ 10^{-3}$	$12,3\ 10^{-9}$	$7,7\ 10^{-9}$
D-E	70	15	0,12	0,17	$1,3\ 10^{-3}$	$5,8\ 10^{-3}$	$9,1\ 10^{-9}$	$4,6\ 10^{-9}$
D-F	70	20	0,04	0,19	$370\ 10^{-6}$	$2,5\ 10^{-3}$	$270\ 10^{-9}$	$250\ 10^{-9}$
E-F	70	10	0,04	0,19	$370\ 10^{-6}$	$2,4\ 10^{-3}$	$270\ 10^{-9}$	$250\ 10^{-9}$
G-F	70	28	0,12	0,30	$1,3\ 10^{-3}$	$5,9\ 10^{-3}$	$9,1\ 10^{-9}$	$4,6\ 10^{-9}$
H-J	70	15	0,12	0,17	$1,3\ 10^{-3}$	$5,9\ 10^{-3}$	$9,1\ 10^{-9}$	$4,6\ 10^{-9}$
H-I	70	10	0,04	0,20	$370\ 10^{-6}$	$2,3\ 10^{-3}$	$270\ 10^{-9}$	$250\ 10^{-9}$
M-I	70	16	0,04	0,21	$370\ 10^{-6}$	$2,3\ 10^{-3}$	$270\ 10^{-9}$	$250\ 10^{-9}$
M-L	70	19	0,04	0,21	$370\ 10^{-6}$	$2,4\ 10^{-3}$	$270\ 10^{-9}$	$250\ 10^{-9}$
L-K	70	7	0,04	0,21	$370\ 10^{-6}$	$2,4\ 10^{-3}$	$270\ 10^{-9}$	$250\ 10^{-9}$
J-K	70	23	0,12	0,23	$1,4\ 10^{-3}$	$6,1\ 10^{-3}$	$9,1\ 10^{-9}$	$4,6\ 10^{-9}$

Loads connected at various busbars

	P min (MW)	P max (MW)	cos ϕ
D	2	10	0,92
E	5	30	0,85
F	2	20	0,88
H	5	20	0,90
I	5	20	0,89
J	10	50	0,87
K	5	30	0,85
L	10	25	0,90
M	2	10	0,89

Capacitor banks

	Q min (Mvar)	Q max (Mvar)
E	2	10
F	0,5	5
J	3	15
K	2	10

Disturbing installation to be connected: AC railway substation

The considered disturbing load is an *AC railway substation*.

This substation basically represents a single-phase variable load of 0 - 15 MVA. The trains that will be fed by the substation are equipped with AC adjustable speed drives for which no final technological choice has yet been made.

- **Identify the main disturbances that will be generated by this installation at the PCC.**
- **Assess the acceptable emission limits for these disturbances, from the grid operator's point of view. This assessment has to be based upon the recommendations and the methodologies developed in IEC reference documents IEC 61000-3-6, 61000-3-7 and 61000-3-13 (available on Moodle).**
- **Calculate the expected disturbances emissions and compare the results to the recommended limits calculated before.**
- **Discuss possible technological choices and/or mitigation techniques and/or connection possibilities, if needed, and provide quantified estimates.**
- **Finally, the possibility of connecting of a 25 MVA biogas cogeneration plant in the same subtransmission grid in the near future will have to be considered. What will be the possible influence of this future cogeneration unit on your previous conclusions? Do not replicate all your calculations but estimate the major trends and provide some figures.**

Practical instructions

- Check that your grid has a satisfying steady-state behavior (load-flow*) in the absence and in the presence of the new load* and, if needed, adjust some suitable parameters (which ones ?).
- You are supposed to collect the needed information that could be missing and/or make reasonable assumptions when necessary. In that perspective, the choice of suitable technological solutions is part of the global assessment.
- You are also supposed to identify and consider the various relevant operation configurations, for the disturbing load to be connected as well as for the existing grid.
- As far as calculation is concerned, you are free to choose the approach/methodology, and the necessary tool(s) and models for making the assessment. In any case, compare the obtained results with a very simple first evaluation that would be based on the use of simplified formulas, as seen in some parts of the course.

	AC railway substation to be connected on busbar	Possible future cogeneration unit to be connected on busbar
Group 1	E	F
Group 2	K	L
Group 3	F	G
Group 4	J	J
Group 5	L	I
Group 6	I	L
Group 7	H	J
Group 8	K	K
Group 9	E	D
Group 10	F	E
Group 11	L	K
Group 12	I	H

Biogas cogeneration unit - electrical characteristics:

S_n = 25 MVA, U_n = 6 kV
Round rotor type synchronous machine

Machine parameters: Simulink/Simscape/Power Systems *Synchronous Machine p.u. Standard* block

- Synchronous reactance: 1,81 p.u.
- Transient reactance: 0,30 p.u.
- Subtransient reactance: 0,23 p.u.

Machine transformer: S_n = 25 MVA, U_n = 6,5 kV / 73 kV, u_{cc} = 10%