Assignment I

Students are required to evaluate the impact of the presence of Dispersed Generation (DG) on a HV distribution grid, described next.
A final report should be provided for evaluation purposes. The assignment can be developed in groups of 2 students.

Figure 1 describes the single line diagram of the network, which is fed from a 220 / 60 kV substation. Figure 2 describes the same network with 8 DG units of different technologies that exploit also different primary power sources. Tables 1 – 7 contain the network branch data and load and generation profiles data needed to build the system model for steady state analysis.

A steady state analysis is required to evaluate the impact on the network, in peak and valley hours, due to the presence of these DG units in what concerns:

- Active and reactive losses;
- Voltage profiles in the network busses;
- Congestion levels in the different branches.

The study to be performed should follow a 3-step approach, as follows:

1) Grid operation with no DG connected;
2) Grid operation with connected GD under the prescribed conditions in Table 6 and table 7;
3) Grid operation under an active management strategy, involving the definition of strategies for the control of reactive power from DG units. This means that suggestions regarding the value of the reactive power to be injected by DG units should be given and justified for the two operating scenarios (peak and valley hours). A trial and error approach exploiting engineering rules is suggested to be used for this purpose.

Any load flow tool can be used to develop these studies. Power World Simulation software can be accessed in the following link:
https://drive.inesctec.pt/s/aPGZoCjnyrD7dki

MATPOWER (https://matpower.org/), a simulation tool for Matlab, can also be used.

Notes:
Tables with data contain more data than the required for this network analysis.
Voltages in all nodes should be controlled at around ±10 % of the nominal value.

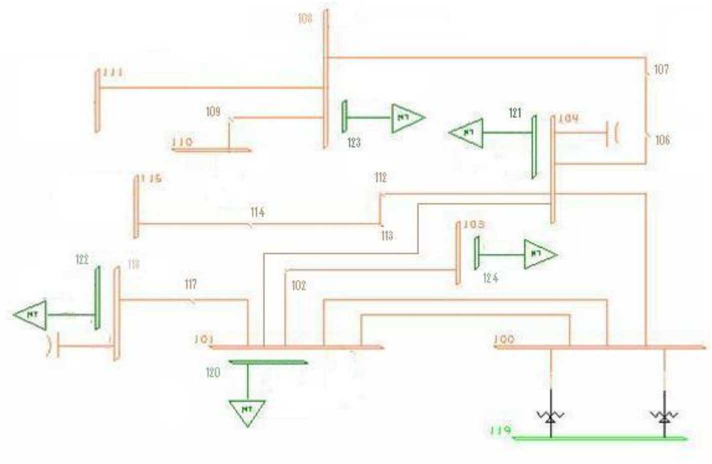

Figure 1 – HV network without DG

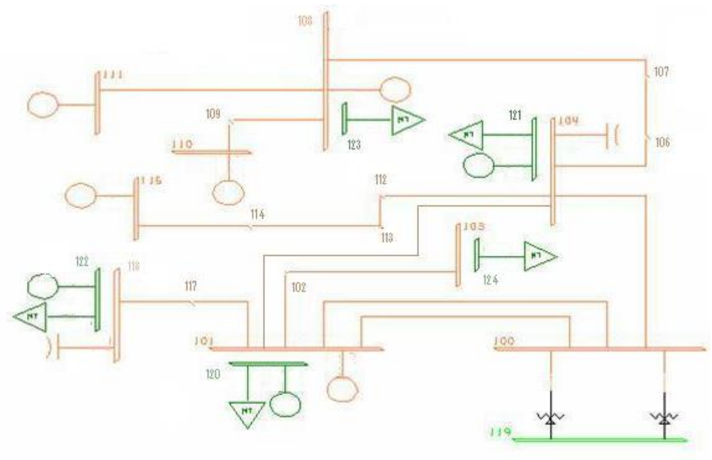

Figure 2 – HV network with DG

Base values are: Sb = 100 MVA, Ub = 60 kV

Table 1 – Line data

Line data						
from	**to**	**Resistance (pu)**	**Reactance (pu)**	**Susceptance (pu)**	**S line (MVA)**	**Line length (Km)**
100	101	0.00	0.01	0.00	54.18	1.46
100	101	0.00	0.01	0.00	69.3	1.45
101	102	0.08	0.20	0.00	29.61	19.92
102	103	0.02	0.05	0.00	27.09	4.83
101	104	0.05	0.16	0.00	34.65	4.83
100	104	0.03	0.08	0.02	69.3	42.64
101	117	0.11	0.33	0.00	32.76	16.98
104	106	0.01	0.18	0.00	27.09	18.07
106	107	0.08	0.20	0.00	30.555	33.23
107	108	0.06	0.17	0.00	34.65	0.20
108	109	0.05	0.22	0.00	22.05	20.47
109	110	0.03	0.06	0.00	22.05	0.23
108	111	0.04	0.13	0.00	34.65	1.00
104	112	0.01	0.03	0.01	69.3	5.73
112	113	0.00	0.01	0.00	34.65	13.17
113	114	0.03	0.06	0.00	28.665	21.45
114	115	0.00	0.01	0.00	34.65	0.36
117	118	0.01	0.02	0.00	27.09	7.28

Table 2 – Power Transformers Data

From	To	X_f (p.u)
I	**J**	**100 MVA base**
119	100	0.0914
119	100	0.0914
101	120	0.428
101	120	0.428
104	121	0.3968
104	121	0.3968
118	122	0.515
118	122	0.515
103	124	0.6333
103	124	0.6533
108	123	0.810

Note: Take in consideration that all power transformers have OLTC capable of voltage regulation between 0.9 and 1.1 p.u. in steps of 2.5 %.

Table 3 – Peak Hours Load

Peak Hours Load		
Bus	Active Power (MW)	Reactive power (Mvar)
111	0.08	0
115	0.02	0
121	39.45	6.72
122	21.64	3.99
123	5.10	1.25
124	9.87	3.29
120	25.33	3.87

Table 4 – Valley Hours Load

Valley Hours Load		
Bus	Active Power (MW)	Reactive power (Mvar)
111	0.032	0
115	0.0008	0
121	15.78	2.688
122	8.656	1.596
123	2	0.5
124	3.948	1.316
120	10.132	1.548

Table 5 – Capacitor Banks

Capacitor Banks			
Bus	N of taps	Value per tap	Total Reactive Power (Mvar)
118	4	0.84375	3.375
202	4	1.0125	4.05
300	4	1.00125	4.005
201	3	1	3
201	3	1	3
104	8	1	8
104	8	1	8
307	3	1	3
120	10	1	10
124	10	1	10
123	10	1	10

Table 6 – Peak Hours DG Production

Peak Hours DG Production					
				Reactive Power Limits (Mvar)	
Machine Type	Bus	Pgen (MW)	Qgen (Mvar)	Max	Min
S	110	6.52	2.61	3.13	-3.13
S	115	5.99	2.40	2.88	-2.88
A	108	6.19	2.48	2.97	-2.97
A	120	5.68	2.27	2.73	-2.73
S	121	0.37	0.15	0.18	-0.18
S	121	0.28	0.11	0.13	-0.13
S	120	6.13	2.45	2.94	-2.94
A	120	1.95	0.78	0.94	-0.94
A	120	3.72	1.49	1.79	-1.79
S	111	5.57	2.23	2.67	-2.67
A	122	0.22	0.09	0.10	-0.10
S	120	3.64	1.46	1.75	-1.75
S	121	6.74	2.70	3.24	-3.24
S	121	5.57	2.23	2.67	-2.67
S	120	4.18	1.67	2.01	-2.01
S	122	0.10	0.04	0.05	-0.05
S	122	3.23	1.29	1.55	-1.55
S	101	23.84	9.54	11.44	-11.44

Table 7 – Valley Hours DG Production

Valley Hours DG Production				
			Reactive Power Limits (Mvar)	
Machine Type	Bus	P (MW)	Max	Min
S	110	4.56	3.13	-3.13
S	115	4.19	2.88	-2.88
A	108	6.19	2.97	-2.97
A	120	5.68	2.73	-2.73
S	121	0.26	0.18	-0.18
S	121	0.20	0.13	-0.13
S	120	4.29	2.94	-2.94
A	120	1.95	0.94	-0.94
A	120	3.72	1.79	-1.79
S	111	3.90	2.67	-2.67
A	122	0.22	0.10	-0.10
S	120	2.55	1.75	-1.75
S	121	4.72	3.24	-3.24
S	121	3.90	2.67	-2.67
S	120	2.93	2.01	-2.01
S	122	0.07	0.05	-0.05
S	122	2.26	1.55	-1.55
S	101	16.69	11.44	-11.44

Note: In valley hours, the distributed generation units operate with unitary power factor