Automation of Energy Systems – A. Leva

Project for the academic year 2022/2023

Consider an AC system at frequency f_0=50Hz composed of three generators $G_{1\text{-}3}$ and four loads $L_{1\text{-}4}$, that can operate in two configurations referred to in the following as A and B. In configuration A G_1 and G_2 feed L_1 and L_2 while G_3 feeds L_3 and L_4; in configuration B the three generators and the four loads form a unique grid. All generators have a first-order dynamics and the characteristics reported below; the minimum manageable power equals 15% of the nominal one for all of them.

	Nominal power [MW]	Time constant [s]	Inertia [kJ/(r/s)^2]	Cost rate curve
G_1	100	10	20	$c(P_g) = 0.5+1.5(P_g-95)^2$
G_2	50	5	10	$c(P_g) = 1+3(P_g-48)^2$
G_3	150	20	10	$c(P_g) = 1.5+4(P_g-140)^2$

We address a 3-hours period divided in six 30-minutes slots $S_{1\text{-}6}$, in which the active powers taken by the loads [MW] behave as shown in the following table.

	S_1	S_2	S_3	S_4	S_5	S_6
L_1	10	20	20	20	10	10
L_2	50	50	100	100	100	50
L_3	80	80	80	80	120	120
L_4	30	30	30	10	10	10

All of the above said, your task is to carry out the assignments listed below.

1. Set up a primary/secondary/tertiary power/frequency control for configuration A, aiming for both sub-grids to have a ramp electric power variation of 5MW over 10s result in a normalised frequency error $\delta\omega$ that never exceeds a magnitude of 0.05 and vanishes in 15 minutes at most; make the secondary control contributions proportional to the generator nominal powers.
2. Determine the optimal generator pool and the optimal tertiary biases for the six time slots in the sub-grid with G_1 and G_2, having as objective the minimum total expenditure, and assuming the given load behaviour as the required forecast. Simulate a 3-hours period with the nominal load behaviour, plot the results you deem relevant and comment.
3. Set up a primary/secondary/tertiary power/frequency control for configuration B, aiming for the unique grid to the same specifications provided above for the two sub-grids of configuration A, and assuming that G_1 and G_3 must provide equal secondary contributions and overall take 80% of the burden (if feasible, otherwise resort to proportional distribution as for configuration A).
4. Determine the optimal generator pool and the optimal tertiary biases for the six time slots in configuration B, having as objective to minimise the expenditure of the generator pool made of G_1 and G_3. Simulate a 3-hours period with the nominal load behaviour, plot the results you deem relevant and comment.
5. Discuss how control should manage the transition from configuration A to B and *vice versa*, proposing a solution in terms of block diagrams. Supporting your findings with simulations is not required (but not forbidden either).

Once you carried out the task required above, proceed as follows.

- Create a presentation of approximately 15 slides to describe your work.
- With the aid of the said presentation create a screencast of maximum 15 minutes (first sharp constraint) where all the team members (second sharp constraint) have to participate into the explanation to a significant extent. The team is expected to be composed of four members.
- Name the created Modelica model **Project.mo**, the presentation **Slides.xxx** and the screencast **Video.yyy**, the **xxx** and **yyy** extensions depending on the file format you use (for the screencast mp4 is preferred, but not mandatory).
- Create a text file named **Team-members.txt**, containing the family name(s), given name(s) and person codes of all the members of the team.
- Pack the four files above into a single compressed file, and name that file

  AES-2023-Name.zzz

  where the **zzz** extension depends on the particular compressed format employed, while **Name** is the (first) family name of the team member who comes alphabetically first.
- Upload only the so created compressed file using the Webeep folder before taking the written test. Only the member whose family name appears in the compressed file name needs to upload, that will be valid for the entire team.