Automation of Energy Systems – A. Leva

Project for the academic year 2024/2025

An AC grid at nominal frequency f_o=50Hz contains three generators $G_{1\text{-}3}$, all described by a 2nd-order dynamics with time constants τ_1=20s and τ_2=4s. The table below lists their nominal (rated) powers P_{nom}, maximum efficiency powers P_{opt}, minimum manageable load powers P_{mml}, production costs at maximum efficiency c_{opt} and at minimum manageable load c_{mml}; the network inertia J is 55kJ/(r/s)^2.

	P_{nom} [MW]	P_{opt} [MW]	P_{mml} [MW]	c_{opt} [€/MWh]	c_{mml} [€/MWh]
G_1	50	45	10	50	80
G_2	100	90	20	50	120
G_3	120	105	50	60	90

Consider a 10-hours period in which the total demand of electric power P_e takes values multiple of 30MW in the range from 30 to 240MW included, varying in a stepwise manner by 30 MW (up or down) at the beginning of each hour. Your assignments are listed below.

1. For each value of P_e, having as objective the minimum total expenditure, determine the optimum generator pool and, if that pool contains more than one generator, the optimum generation distribution (i.e., the tertiary biases).
2. Set up and tune a primary/secondary/tertiary power/frequency control for the grid, aiming at a frequency settling time of 10 minutes at most after a P_e step and taking sensible decisions about the frequency *nadir* (the minimum value reached in the case of a positive step); assume for simplicity that the deactivation of a generator can be obtained simply by applying zero command, and make the steady-state secondary contributions exhibit the same ratios as the generator rated powers.
3. Create a block-oriented Modelica model for the so controlled grid and subject it to three different P_e profiles of your choice, compliant with the specification above, plus some small step-like variations at random times to assess the effect of errors in the forecasting of P_e; refine the controller tuning if you deem this convenient, justifying your decisions and commenting on the obtained results.

Once you carried out these tasks, 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 compressed one named **AES-2025-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 by that name comes alphabetically first.
- Upload only the above 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.