Automation of Energy Systems

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Reg. No. ____________________________

Last name ____________________________

Given name(s) ____________________________

Signature ____________________________

- Answer the questions in the spaces provided.
- If you run out of room for an answer, continue on the back of the page.
- Hand in *only* this booklet. No additional sheets will be accepted.
- Scoring also depends on clarity and order.

1. Consider an islanded electric generator with power and frequency control realised via a PI block. Assume the generator to be described by a linear model, the input being a command in the range 0–1 and the output the variation ΔP_g of the generated power, given by

$$G(s) = \frac{100}{(1 + 2s)(1 + 0.2s)}$$

and the network equivalent time constant T_A to be $5\,s$ (the nominal frequency is $50\,Hz$).

   (a) Draw the block diagram of the control system, indicating with ΔP_e the electric power demand variation.

(b) Tune the PI for a cutoff frequency of $0.1\, r/s$.

(c) Compute the obtained phase margin and comment on how this is influenced by the PI gain.

2. Consider a system in which a body of thermal capacity $C = 8000\,J/°C$ is connected to a heater of maximum power $P_h = 1\,kW$ described by a first-order model with a 0–1 command as input, the power as output, and a time constant τ_h of $8\,s$. Let a disturbance be provided by an external temperature T_e, toward which the body disperses heat through a thermal conductance $G_e = 20W/°C$.

   (a) Draw an electric equivalent of the system.

   (b) Express the steady-state heater consumption as a function of the temperature set point, assuming zero steady-state error, and of T_e. Discuss the role of G_e in this context.

(c) Synthesise a temperature controller for a closed-loop settling time of 5 min assuming a linear system behaviour (i.e., no heater power saturation). Estimate, based on that limitation, the maximum temperature rise rate. Comment on the obtained results.

3. Illustrate the “turbine follows” control scheme for electric generators, indicating and briefly motivating its main advantages and disadvantages.

4. Briefly explain what is the load flow problem, why it is relevant in the context of electric networks, and how its solution can ba integrated in the overall control and optimisation problem.