Automation of Energy Systems

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Reg. No. _____

Last name _____

Given name(s) _____

- 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 electric network with three generators. Indicate with P_{gi}, $i = 1 \dots 3$, their generated powers, and with P_e the forecast total power demand. All the generator are characterised by a cost rate model with a linear and a quadratic term, and have operational limits in the form $P_{gi}^{\min} \leq P_{gi} \leq P_{gi}^{\max}$.

   (a) Draw and briefly comment (no computations are required but symbols need defining) a block diagram representing the generators connected to a synchronous rigid network, endowed with primary and secondary power and frequency control.

(b) Write the KKT equations for the so defined generation distribution optimisation problem when all the generators are active and participating to the network control.

2. Consider a thermal system in which a solid body, of mass $M = 50\,kg$ and specific heat $c = 800\,J/kg°C$, is connected to a heater, and disperses heat toward a fixed external temperature T_e through a thermal conductance $G = 60\,W/°C$.

   (a) Draw an electric equivalent of the system.

   (b) Determine the power required to the heater so that the system can maintain, at steady state, a temperature difference of $25 \circ C$ between the body and the external environment.

(c) Tune a PI to control the body temperature T acting on the heater power P_h, so that settling time of the controlled variable's response to a set point step does not exceed 5 minutes.

3. With reference to the coordinated control of power and frequency for an islanded generator, the two most commonly employed regulator structures are the PI and the PID one. Assuming that the generator transfer function is first-order, illustrate the guidelines for tuning a controller with the two structures just mentioned, and synthetically discuss pros and cons of both.

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