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. An islanded electric generator in an AC network with nominal frequency $f_o = 50Hz$ is described by the transfer function

$$G(s) = \frac{P_n}{1 + sT}$$

from the command θ, in the range 0–1, to the variation ΔP_g of the generated power, where $P_n = 40MW$ and $T = 4s$.

(a) Draw the block diagram representing the generator connected to a local network of inertia J, and determine the said inertia so that the equivalent time constant T_A be 8 s.

(b) Tune a PID power/frequency controller for a closed-loop settling time of $10s$ and a phase margin of 60°; report the obtained frequency response, together with the phase margin computations, on the logarithmic sheet following this page.

(c) Quantify – also approximately – the maximum closed-loop settling time compatible with the phase margin requirement above, in the absence of derivative action.

2. Consider a body of thermal capacity $C = 20kJ/{}^\circ C$ connected to a heater described by a first-order model, with maximum power $P_h = 2kW$, and time constant $\tau_h = 10s$. The body releases heat to a prescribed external temperature T_e through a thermal conductance $G = 200W/{}^\circ C$, and is subjected to a radiative power disturbance P_{rad}.

   (a) Draw an electric equivalent of the system.

(b) Draw and tune a feedback temperature control scheme for a closed-loop dominant time constant of $50s$, guaranteeing asymptotic rejection of a step-like P_{rad}.

(c) Determine the obtained phase margin.

3. Illustrate primary and secondary control in AC electric networks, evidencing their role, characteristics, typical time scales, and potential interplay.

4. Illustrate the "daisy chain" actuation scheme, explaining what are its most typical uses in thermal control systems.