Automation of Energy Systems

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Reg. No. _____

Last name _____

Given name(s) _____

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- 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, and let the transfer function from the command θ, in the range 0–1, to the normalised variation δP_g of the generated power, be

$$g(s) = \frac{320}{1 + 15s}.$$

   (a) Draw the block diagram representing the generator connected to a local network, assuming an equivalent time constant T_A of $10\,s$.

(b) Tune a power/frequency controller in the form of a real PID for a phase margin of 50° and a closed-loop dominant time constant of $5\,s$.

(c) Express the transfer function from the electric power demand variation ΔP_e to the normalised frequency error $\delta\omega$.

2. Consider a thermal system in which a body of capacity $C = 20$ kJ/°C is heated by a combustor. The fuel calorific power is $HH = 48$ MJ/kg, and the combustion efficiency η_c varies from a minimum of 0.6 to a maximul of 0.8. The body disperses heat through a thermal conductance $G = 70$ W/°C, to a prescribed external temperature T_e, and is subject to a disturbance radiative power P_r.

   (a) Draw an electric equivalent of the system.

(b) Determine a linear regulator acting on the fuel flow rate w_f [kg/s] to control the body temperature T, reasoning on the worst-case situation, so that the settling time of the response of the controlled temperature to a set point step variation does not exceed $10\,min$.

(c) Estimate (even roughly) the same settling time in the best-case situation.

3. Describe the "boiler follows", policy for the control of thermoelectric generators, highlighting and briefly justifying its major advantages and disadvantages.

4. Illustrate the "time division output" actuation scheme, indicating the main reasons that make its application advisable, and commenting on how its base period has to be chosen.