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 its transfer function – having as input the command $\theta \in [0, 1]$ and as output the variation ΔP_g of the generated power expressed in MW – be

$$G(s) = \frac{10}{1 + 2s}.$$

   (a) Assuming a network inertia of $10kJ/(r/s)^2$, determine the network equivalent time constant T_A.

   (b) Draw the block diagram representing the generator, the network and a primary plus secondary frequency controller in PI form.

(c) Tune the controller for a settling time of 20s and determine the corresponding phase margin.

2. Consider a thermal system in which a body of capacity $C = 20$ kJ/°C is connected to two daisy-chained heaters (hereinafter H1 and H2). Both can be described by a first-order system with a $[0, 1]$ command input, a gain of $2kW$ and a time constant of $5s$, however the efficiencies of H1 and H2 (defined as power released to the body over consumed power) are respectively 0.5 and 0.8. The body disperses heat through a thermal conductance $G = 80W/°C$ toward an exogenous temperature T_e,

   (a) Draw an electric equivalent of the system.

   (b) Draw a scheme to control the body temperature T with a single regulator, daisy-chaining the heaters in the correct order

(c) Tune the regulatore for a worst-case settling time of 30 minutes.

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

4. Explain, with the need of convenient schemes if you deem it useful, what is meant for "time division output" actuation, with particular reference to its use in the control of thermal systems.