Automation of Energy Systems

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11 September 2013

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Last name _____

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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 electric network with two identical generators, where power and frequency control is realised via two proportional primary blocks of gain k_p, and a single integral secondary block of gain k_i. Assume both generators to be described by a linear model having a command in the range 0–1 as input, a gain of $100MW$, and a time constant of $20s$.

   (a) Draw the block diagram of the controlled network.

   (b) Assuming that the secondary control contribution is equally divided, tune the control scheme for a zero steady-state normalised frequency error, and a closed-loop cutoff frequency of about 0.3 r/s.

(c) Express the transfer function from electric power variation ΔP_e to normalised frequency error $\delta\omega$, in the presence of the so tuned scheme.

2. Consider a system in which a body of thermal capacity C is connected to a heater of maximum power P_h, described by a first-order model with a command in the range 0–1 as input, the released power as output, unity gain, and a time constant τ_h. Finally, let a disturbance be provided by an exogenous power Q_d, released to the body, that additionally disperses heat through a thermal conductance G_e to a fixed external temperature T_e.

   (a) Draw an electric equivalent of the system.

   (b) Draw and tune a feedback temperature control scheme for a set point step response settling time of τ_{set}, motivating the choice of the controller structure.

(c) Assuming that the heater power P_h is measurable, explain – *also qualitatively if preferred* – which considerations could lead to the opportunity of introducing a cascade control structure having that power as the inner loop's controlled variable.

3. Illustrate, with the help of a block diagram if deemed convenient, the "turbine follows" control scheme for thermo-electric generators, indicating and briefly explaining its advantages and disadvantages.

4. Briefly explain what is the "time division output" actuation scheme, evidencing its usefulness and its most typical applications.