Automation of Energy Systems

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Reg. No. ______________________________

Last name ______________________________

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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 AC electric generator with a nominal (maximum) power $P_n = 5MW$ and a first-order dynamics with time constant $\tau = 4s$ feeds a local load at frequency $f_o = 50Hz$, and is endowed with power and frequency control in PI form.

   (a) Draw the block diagram of the control system.

   (b) Assume that the equivalent time constant of the local network is $T_A = 8s$, and determine the total inertia J accordingly.

(c) Tune the controller for a closed-loop dominant time constant of $10s$.

2. Consider a system in which a thermal capacity $C = 10^4 J/{}^\circ K$ is connected to a heater with maximum power $P_h = 5kW$, a per-unit command u_h and a first-order dynamics with time constant $\tau_h = 10s$. Let an external temperature T_e act as a disturbance, the capacity dispersing heater toward it through a loss conductance $G = 15W/{}^\circ K$.

   (a) Draw an electric equivalent for the system.

   (b) Draw and tune a scheme to control the capacity temperature T through the heater command u_H, for a closed-loop settling time of $150s$.

(c) Assume that the heater efficiency η_h depends linearly on u_h, taking the values 0.3 and 0.6 for $u_h = 0.1$ and $u_h = 1$, respectively. Express the power consumed by the heater as a function of the temperature set point T^o and of T_e.

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

4. Draw (without computations) the typical two-loops scheme to keep a temperature within two limits using a heating and a cooling actuator, and briefly illustrate the advantages of the said scheme with respect to a split-range one with a single control loop.