



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. Consider an electric network with two identical generators, having as transfer function from the throttling command θ , in the range 0–1, to the variation ΔP_g of the generated power, the expression

$$G_{1,2}(s) = \frac{P_n}{1 + s\tau},$$

where $P_n = 20\text{MW}$ and $\tau = 20\text{s}$.

- (a) Draw the block diagram representing the two generators connected to the network, indicating respectively with J [MW/MJ] and f_o [Hz] its inertia and nominal frequency.

(b) Setting $J = 1/(25\pi^2)$ and $f_o = 50 \text{ Hz}$, determine the characteristic time constant T_A of the network.

(c) Lumping the two generators together into an equivalent one, tune a compound power/frequency controller in the form of a PI for a phase margin of 45° .

- (d) Convert the so obtained PI into a primary and a secondary controller expressed respectively as K_p and K_i/s , and propose reasonable values for the secondary distribution coefficients $\beta_{1,2}$. [Hint: keep in mind that the two generators are identical]

2. Consider a thermal system in which a body of capacity $C = 12 \text{ kJ/}^\circ\text{C}$ is heated by a combustor burning fuel with calorific power $HH = 50 \text{ MJ/kg}$, and having a combustion efficiency $\eta_c = 0.8$. Said body disperses heat through a thermal conductance $G = 30 \text{ W/}^\circ\text{C}$, to a prescribed external temperature T_e .
- (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 , so that the settling time of the response of the controlled variable to a set point step variation does not exceed 5 min.
- (c) Synthetically discuss the effects of the fuel calorific power and of the combustor efficiency on the obtained results.

3. Briefly describe the “boiler follows”, “turbine follows” and “sliding pressure” policies for the control of thermoelectric generator, indicating and comparing their major advantages and disadvantages.

4. Explain, with the need of convenient schemes if you deem it useful, what is meant for “split range” actuation, with specific reference to its use in the control of thermal systems.