
# Automation of Energy Systems

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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 thermoelectric generator, where the transfer function from the throttle valve command $\theta$ to the normalised generated power $P_g/P_n$, $P_n$ being the nominal power, is

$$g(s) = \frac{1}{1 + s\tau},$$

while $T_A$ is the network time constant.

   (a) Draw a block diagram representing the generator and the network with primary and secondary frequency control, expressed in the standard $(k_p, k_s)$ form.

(b) Express the steady-state frequency error in the absence of secondary control as a function of the system and control parameters, and of the amplitude $\Delta P_e$ of the electric power step that provoked it.

(c) Express the control bandwidth as a function of the system and control parameters, in the presence of both primary and secondary control.

2. Consider a system in which a body of thermal capacity $C$ is connected to a heater of maximum power $P_h$, described by an algebraic model with a command in the range 0–1 as input, and the released power as output. The body dispersed heat through a thermal conductance $G_{bc}$ to a containment of thermal capacity $C_c$, which in turn exchanges heat via a conductance $G_{ce}$ to a fixed external temperature $T_e$.

   (a) Draw an electric equivalent of the system.

(b) Draw and tune a PID-based feedback control scheme for the body temperature, with a prescribed phase margin $\varphi_m$.

(c) In the presence of the designed controller, evaluate the settling time $\tau_{set}$ of the response of the controlled temperature to a set point step.

3. Illustrate the "sliding pressure" control scheme for thermo-electric generators, outlining and briefly explaining its advantages and disadvantages.

4. Explain, possibly by means of some block diagram, what is meant for "split range" actuation, and what are its most typical uses in thermal control systems.