
# Automation of Energy Systems

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20 July 2012

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 islanded thermoelectric generator, and let the transfer function from the throttle valve command $\theta$ to the normalised generated power $P_g/P_n$, where $P_n$ is the nominal (registered) power, take the form

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

while $J$ is the total network inertia seen at the alternator shaft, and $\omega_o$ the desired frequency.

(a) Draw a block diagram representing the generator and the network with primary and secondary frequency control, and express the so obtained compound regulator as a PI one in the form

$$R_{ps}(s) = K\left(1 + \frac{1}{sT_i}\right)$$

by relating $K$ and $T_i$ to the primary and secondary gains ($k_p$ and $k_s$, respectively).

(b) Suppose that a phase margin $\overline{\varphi}_m$ has to be achievable for some value of $K$, and determine the consequent lower bound $T_{i,min}$ for $T_i$. Hint: express and examine the open loop frequency response phase.

(c) Assume that $T_i$ is set exactly to $T_{i,min}$ and determine $K$ so as to achieve $\overline{\varphi}_m$. What can you say about the closed-loop system's stability degree if $K$ is increased or decreased starting from the found value? Would you recommend such a controller tuning? Why?

2. Consider a system in which a body of thermal capacity $C$ is heated by a lossless combustor burning fuel with calorific power $HH$. Take the fuel mass flowrate $w_f$ as the control variable, while a disturbance is provided by variations of an external temperature $T_e$, toward which the body disperses heat through a thermal conductance $G$.

   (a) Draw an electric equivalent of the system.

   (b) Determine a linear regulator such that the settling time of the response of the controlled variable (the body temperature $T$) to a step variation of the corresponding set point be twice the intrinsic system's time constant.

(c) Draw a block diagram representing the so obtained control system, and complete it with an open-loop compensator $C(s)$ for the disturbance $T_e$, assumed perfectly measured. Note: you are *not* requested to determine $C(s)$.

3. Synthetically compare the "turbine follows" and the "sliding pressure" policies for the control of thermoelectric generator.

4. Explain what is meant for "time division output" actuation in thermal control systems, indicating when such a solution is typically advisable, and briefly commenting on how the base period has to be chosen.