Automation of Energy Systems

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19 July 2013

Reg. No. _____

Last name _____

Given name(s) _____

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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 four generators. Indicate with P_{gi}, $i = 1 \dots 4$, their generated powers, and with P_e the forecast total power demand. All the generator are characterised by a cost rate model having the form

$$c_i(P_{gi}) = k_{i0} + k_{i1} P_{gi} + k_{i2} P_{gi}^2$$

while their operational limits are expressed as $P_{gi}^{\min}$, $P_{gi}^{\max}$.

(a) Write the KKT equations for the so defined generation distribution optimisation problem when all the generators are active and participating to the network control.

(b) Write the KKT equations for the same distribution optimisation problem assuming that only generators 1 to 3 are active, generator 3 however not participating to control but producing a fixed power $\overline{P}_{g3}$, and generator 4 is off.

2. Consider a system in which a body of thermal capacity $C = 5000\,J/°C$ is heated by a combustor of efficiency $\eta_c = 0.75$, burning fuel with calorific power $HH = 4 \cdot 10^6\,J/kg$. The body disperses heat through a thermal conductance $G = 20\,W/°C$ toward an external temperature T_e. The fuel mass flowrate w_f is the control variable for the body temperature T, while T_e is a disturbance.

   (a) Draw an electric equivalent of the system.

   (b) Determine a linear regulator such that the settling time of the response of T to a step variation of its set point, assuming a linear system behaviour, does not exceed 4 minutes.

(c) Determine the steady-state value of w_f for a temperature set point of $20\,^{\circ}C$, as a function of T_e.

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

4. Briefly explain what is the "daisy chain" actuation scheme, and summarise its most typical uses.