Automation of Energy Systems

Alberto Leva

9 September 2015

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, each with a nominal power P_n of $50\,MW$, and a first-order dynamics with a time constant τ of $5\,s$. The nominal frequency f_o is $50\,Hz$.

   (a) Determine the network inertia J so at to obtain an overall characteristic time T_A of $10\,s$.

   (b) Draw the block diagram of the network endowed with primary and secondary control. Indicate with k_P the (identical) primary gains, with k_S the secondary one, with $\beta_{1,2}$ the secondary distribution coefficients, and with ΔP_e the electrical power demand variation.

(c) Tune the control system for a phase margin of $40°$, and so that the steady-state secondary contribution of generator 1 be three times that of generator 2.

2. Consider a system in which a body of thermal capacity $C = 500\,J/°C$ is connected to three heaters, each one of maximum power $P_h = 200\,W$. The body releases heat toward a prescribed external temperature T_e, through a thermal conductance $G = 5\,W/°C$.

   (a) Draw an electric equivalent of the system.

   (b) Draw a scheme to control the body temperature with a single PI, daisy-chaining the heaters in the order 1 to 3.

(c) Tune the PI for a dominant closed-loop time constant of $100\,s$.

3. Describe the “sliding pressure” control scheme for electric generators, indicating and briefly motivating its main advantages and disadvantages.

4. Illustrate the problem of optimally distributing the generation of power in an electric network, evidencing the involved quantities, and sketching out a typical solution strategy.