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, and let the transfer function from the throttle valve command θ to the normalised generated power P_g/P_n, where P_n is the registered power, be

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

Let further J be the total inertia seen at the alternator shaft, and ω_o the desired frequency.

(a) Draw a block diagram representing the generator and the network with primary and secondary frequency control in the form of a real PID. For convenience, express that PID as the cascade of a classical "primary plus secondary" block, where the two gains are indicated with k_p and k_s, and of a unity-gain zero/pole block where the time constants of zero and pole are termed T_z and T_p, respectively.

(b) Draw a *qualitative* magnitude diagram of the loop frequancy response with the zero of the primary plus secondary block set to cancel the pole of $g(s)$, illustrating how the frequencies of the zero and the pole of the cascadec block need selecting. (Hint: express the primary plus secondary block in PI form.)

(c) Consequently, evidence the role and importance of the zero/pole block.

2. Consider a thermal system in which a body of mass $M = 100\,kg$ and specific heat $c = 800\,J/kg°C$, is connected to a heater of maximum power $P_{h,max} = 25\,kW$, and disperses heat toward a fixed external temperature T_e through a thermal conductance $G = 120\,W/°C$.

   (a) Draw an electric equivalent of the system.

   (b) Tune a PI to control the body temperature T acting on the heater power P_h, so that the dominant closed-loop time constant be around $10\,min$.

(c) Verify the sizing of the heater according to the obtained results, considering both the steady-state power value and the initial peak caused by a set point step.

3. Illustrate the "sliding pressure" control scheme for electric generators, indicating and briefly motivating its advantages and disadvantages.

4. Explain what is meant for "split range" actuation in a typical thermal control system, also briefly discussing the relationships between the characteristic parameters of the said actuation, and the tuning of the control loop it belongs to.