Automation of Energy Systems

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Reg. No. ____________________

Last name ____________________

Given name(s) ____________________

Signature ____________________

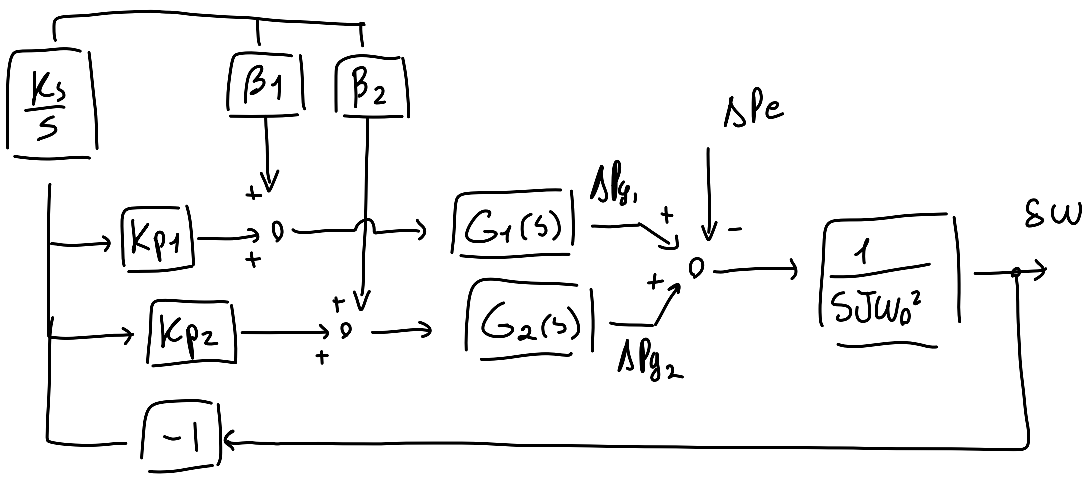
- Answer the questions in the spaces provided.
- If you run out of room for an answer, continue on the back of the page.
- Hand in *only* this booklet. No additional sheets will be accepted.
- Scoring also depends on clarity and order.

1. Consider an electric network with two generators, both having

$$G_{1,2}(s) = \frac{P_n}{1 + s\tau},$$

as transfer function from the throttling command θ, in the range 0–1, to the variation ΔP_g of the generated power, with $P_n = 50\text{MW}$ and $\tau = 10\text{s}$.

(a) Draw the block diagram representing the two generators connected to the network.



?!

(b) Setting the total inerta J to $1/(100\pi^2)$ and the nominal frequency f_o of the network to $50\,Hz$, determine the characteristic time constant T_A.

we can obtain, given

$$P_{n_{TOT}} = 2P_n = 100MW$$

$$T_A = \frac{J\omega_0^2}{P_{n\,TOT}} = \frac{\frac{1}{100\cancel{\pi^2}}\cdot(2\cancel{\pi}50)^2}{100MW} = \frac{\cancel{100}}{\cancel{100}\cdot 10^6} = 10^{-6}\,\text{sec}$$

(c) Tune a power/frequency controller in the form of a PI for a settling time of $100s$ for the compound of the two generators.

$t_{set} = 100\,\text{sec} \rightsquigarrow \tau_c = 20\,\text{sec}$, $\omega_c = 0{,}05\,\text{rad/s}$

to get $\varphi_m = 50°$..

we can set $\beta_1 = \beta_2 = 0.5$ $\quad K_{p1} = K_{p2} = K_p$ because equal generators

we tune $C(s) = K \dfrac{1+sT}{s}$ as usual

$$\to \boxed{2K_p + \frac{K_s}{s}} \to \boxed{G(s)} \to \circ - - -$$

$T \simeq 84 \quad \Rightarrow \quad L(s) = (0{,}028)^2 \dfrac{\cancel{1+sT}}{\cancel{s}^2(\cancel{1+s\tau})} = K \dfrac{1+\cancel{s}T}{\cancel{s}} \dfrac{1}{\cancel{s}J\omega_0^2} \dfrac{P_m}{\cancel{1+s\tau}} \Rightarrow K = 1{,}57 \times 10^{-9}$

having $\quad K \dfrac{1+sT}{s} = K_s \dfrac{1 + 2K_p/K_s\, s}{s}$ $\quad$ BHO

$\downarrow$

$K_s = K$

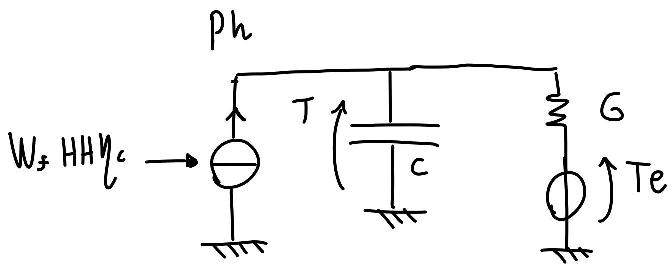
$K_p = T \dfrac{K_s}{2} = 0{,}065 \times 10^{-6}$

(d) Convert the so obtained PI into a primary and a secondary controller expressed respectively as K_p and K_i/s, assuming symmetry also as for the generators' secondary contributions.

WTF are this slut numbers ?!

2. Consider a thermal system in which a body of capacity $C = 12$ kJ/°C is heated by a combustor burning fuel with calorific power $HH = 48$ MJ/kg, and having a combustion efficiency $\eta_c = 0.75$.The body releases heat through a thermal conductance $G = 50$ W/°C, to a prescribed external temperature T_e.

   (a) Draw an electric equivalent of the system.



$$P_h = W_f (HH)\eta_c$$

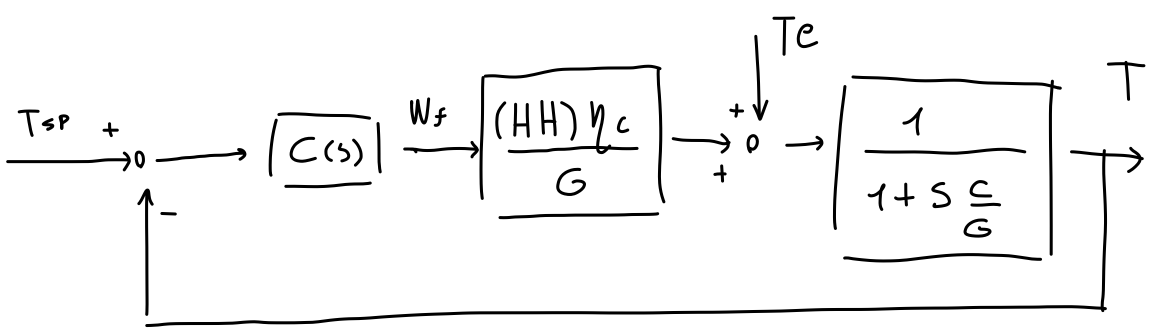
   (b) Determine a linear regulator acting on the fuel flow rate w_f [kg/s] to control the body temperature T, so that the settling time of the response of the controlled variable to a set point step variation does not exceed 10 min.

$$C\dot{T} = W_f (HH)\eta_c - G(T - T_e)$$

$$T = \frac{HH\,\eta_c}{G\left(1+s\frac{C}{G}\right)} W_f + \frac{T_e}{\left(1+s\frac{C}{G}\right)}$$

$t_{set} \le 10\,\text{min}$

$\hookrightarrow \tau_c \simeq 120\,\text{sec}$



$$L(s) = \frac{1}{120s} = C(s)\cdot\frac{(HH)\eta_c}{G}\cdot\frac{1}{1+s\frac{C}{G}}$$

$$\Rightarrow \quad C(s) = \frac{1}{120s}\,\frac{G}{(HH)\eta_c}\left(1+s\,C/G\right) = \frac{(1+240s)}{120s}\left(1.38\times10^{-6}\right)$$

3. List and briefly describe the major policies for the control of thermoelectric generator, indicating and comparing their major advantages and disadvantages.

for the internal control of thermoelectric generator, we have to couple properly our inputs (ϑ_t, ϑ_f) with outputs (e_m, p_m), and depending on this coupling change the control policy.

- We talk about "boiler follow" when ϑ_t control p_m (throttling value has almost instantaneous effect on mech power, perfect when we deal with a load with power variation) but controlling e_m by ϑ_f we have slow dynamic (through the thermal system) causing mechanical stress.
- "turbine follow" Instead uses ϑ_f for p_m (slow load request control) and ϑ_t for e_m (perfect pressure control, avoid stresses)
- "sliding pressure" fixing $\Delta\vartheta_t = 0$ and controlling p_m by ϑ_f (throttling value open!) guarantee minimum turbine stress, no throttling value action. But extremely slow power response (no energy loop helps)

4. Explain, with the need of convenient schemes if you deem it useful, what is meant for "daisy chain" actuation, with specific reference to its use in the control of thermal systems.

"Daisy chain" is an actuation scheme, when dealy with 2 or more actuators provide an actuation logic to manage it by one control variable $u(t)$. with Daisy chain we switch on each actuator in sequence when $u \geq u_{SPLIT\,i}$ the i-th actuator give action u_i.

This is very usefull when you have more actuators, maybe some more efficent than others and you use first the most efficent.

for example in Thermal system if you have 2 or more heaters you decide which one activate first. OR in a central / local T control also decide an actuation logic to the energy to use