Politecnico di Torino
Bachelor degree in Computer Engineering
***AUTOMATIC CONTROL* – (06LSL$_{LM}$ - 06LSL$_{OA}$)**

Surname	**Name**	**id**	**PC**

Exam simulation

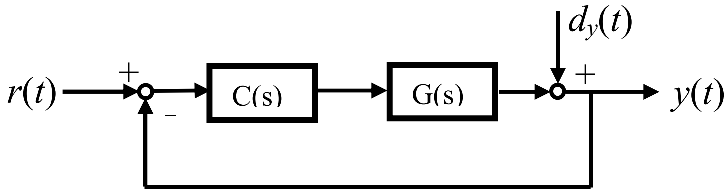
Part I (6 points)

Solve the proposed exercises and write the answers in the table below. For every correct answer, 3 points are added. For every wrong answer, a penalty corresponding to 1 point is subtracted. Every omitted answer leads to a null score. Please provide the correct numerical computations and/or reasoning needed for the answer (otherwise a null score is given).

Exercise	1	2
Answer		

Exercise 1

Consider the feedback control system below:



Where: $G(s) = \dfrac{1}{s^2 + 9s - 10}$, $d_y(t) = \delta\varepsilon(t), |\delta| \le 0.2.$

Design a steady state controller $C_{SS}(s)$ in order to meet the following requirements:

- $|e_r^\infty| \le 0.5$ for r(t) = 0.2 *t*
- $|y_{d_y}^\infty| \le 0.25$.

A) $C_{SS}(s) = \dfrac{4}{s}$

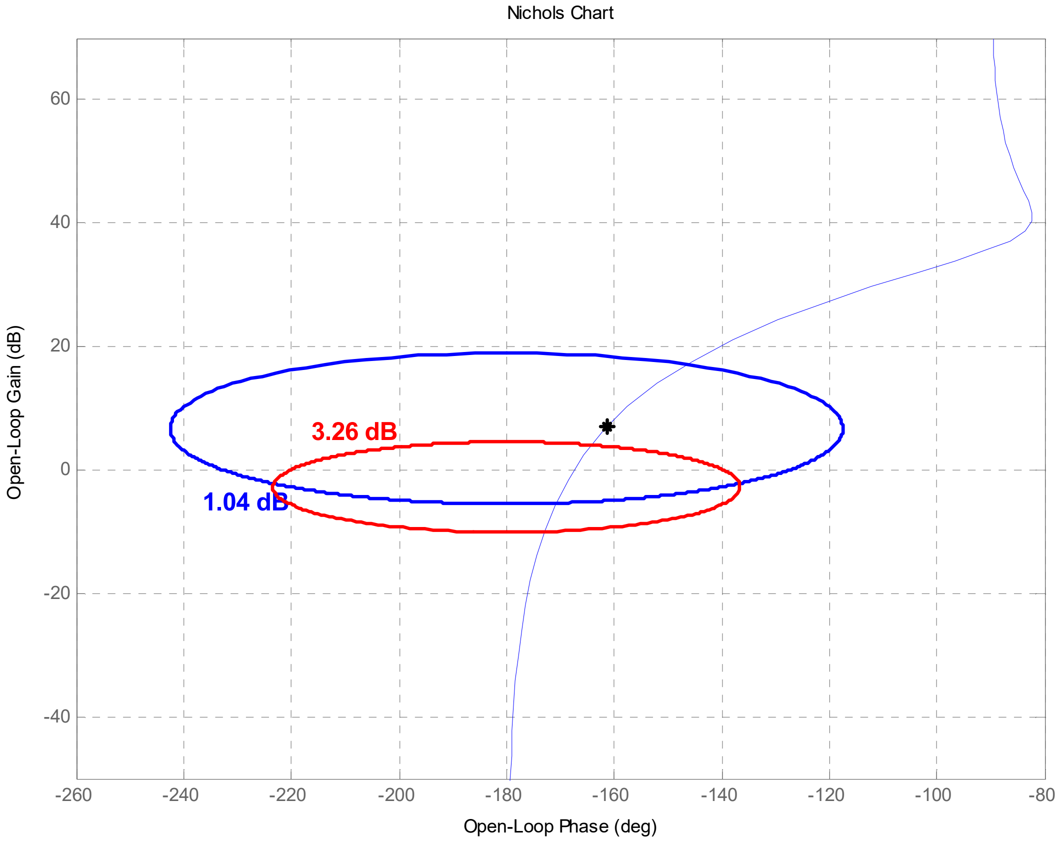
B) $C_{SS}(s) = -\dfrac{4}{s}$

C) It is not possible to design $C_{SS}(s)$ since after the steady state step the closed loop system is not stable.

D) $C_{SS}(s) = \dfrac{2}{s}$

Exercise 2

After the steady state design step, the Nichols plot of the loop function L(s) of a unitary feedback system shows the course reported in the Figure below. (The asterisk indicates the point corresponding to the desired crossover frequency $\omega_{c,des}$)



Which of the following controller function can be reasonably employed in order to satisfy the frequency domain requirements described by the reported constant magnitude loci and the desired crossover frequency.

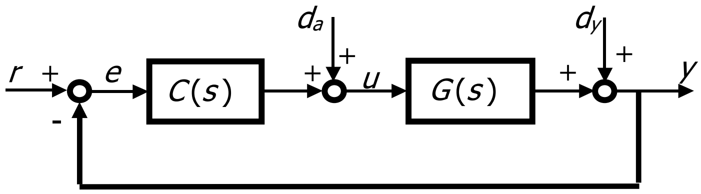
A) A lead-lag network
B) A lag network only
C) A PI controller only
D) More than one among the other reported answers is correct.

Part II (10 points)

Choose and develop one (<u>only</u>) of the following subjects. (The second subject is on the next page)..

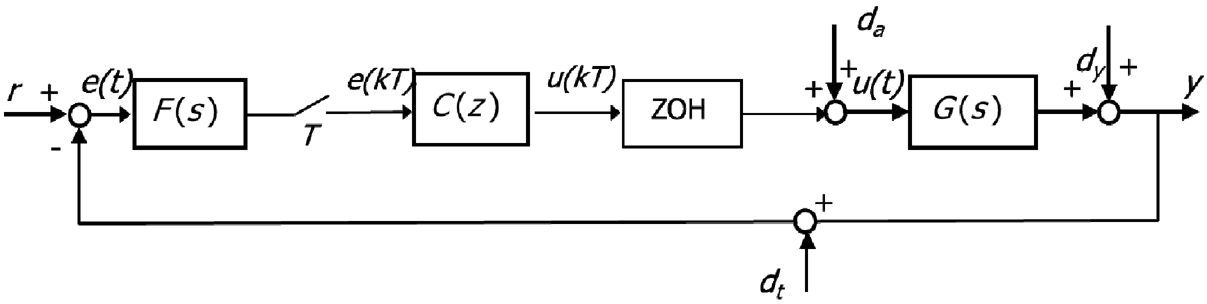
1 - Show that an LTI dynamical system is internally asymptotically stable iff all its natural modes are convergent.

2 – Show that, in the feedback control system structure below (supposed stable), the condition $\left|y_{d_a}^{\infty}\right| = 0$ when $d_a(t)$ is constant, is achieved either when C(s) contains a pole at the origin or when G(s) contains a zero at the origin.



Part III (17 points)

Consider the feedback control structure below.



Where

$$G(s) = \frac{3.3 \cdot 10^4}{s^2} \quad d_a(t) = \delta_a \varepsilon(t), |\delta_a| \leq 0.2 \quad d_y(t) = \delta_y (1 + \sin(\omega_y t)), |\delta_y| \leq 0.5, \; \omega_y \leq 240 \, \text{rad/s}$$

Assume a sampling time $T_s = 4.5 \cdot 10^{-5}$ s, design a digital controller C(z) in order to meet the following requirements:

- $\left|y_{d_a}^{\infty}\right| \leq 0.0125$
- $\left|y_{d_y}^{\infty}\right| \leq 0.5 \cdot 10^{-2}$
- $\hat{S} \leq 16\%$;
- $t_{s,2\%} \leq 0.002$ s
- $\max_t|u(t)| \leq 6$ in the presence of a step reference signal with amplitude 0.001

At the end of the design evaluate, through simulation, the maximum value of the controlled output y(t) when both a step reference signal with amplitude 0.001 and the input disturbance $d_a(t)$ are acting on the system.

Set MatLab path `>> cd D:\`

Steady state requirements analysis and design (4 points, quit the exercise evaluation in the presence of either a "destabilizing" steady state controller or the wrong type of the control system)

Report the expression of the steady state controller in the form $C_{SS}(s) = \dfrac{K_c}{s^h}, K_c = \ldots, h = \ldots$

$C_{SS}(s) =$

Transient and other requirements analysis (2 points)

Design procedure description (5 points)
Please resume and deeply motivate all the design steps performed to obtain the final controller.

Report the expression of the final analog controller in the **dc-gain form**
(e.g. $C_0(s) = \dfrac{K_c}{s^r}\dfrac{1+s/\omega_D}{1+s/(m_D\omega_D)}, K_c = ..., r = ..., \omega_D = ..., m_D = ...$, **this is only an example**!!!!)
(If the expression of C$_0$(s) is missing: quit the exercise evaluation. -1 point if provided in the wrong form

C$_0$(s) =

Report the expression of the final digital controller in the polynomial form

C$_d$(z) = discretization method

Details on the Butterworth anti-aliasing filter (**if designed and not needed: –2 points**)
ω_h = γ = ω_f = n =

Performance evaluation (5 points)
Use simulation in order to evaluate the achieved performance.
(0,5 each correct evaluation, 0 if the evaluation is wrong or missing
0,5 if the requirement has been satisfied (within 5%),
0 for each unsatisfied requirement with an error > 5%
-0,5 for each unsatisfied requirement with an error > 15%
-1 for each unsatisfied requirement with an error > 30%)

- $\left|y_{d_a}^{\infty}\right| =$
- $\left|y_{d_y}^{\infty}\right| =$
- $\hat{S} =$
- $t_{s,2\%} =$
- $\max_t|u(t)| =$ in the presence of a step reference signal with amplitude 0.001

Final evaluation after design
(1 point if the evaluation is correct within 10%, 0 point if it is wrong or missing)

$\max_t |y(t)| =$

Save results **`>> save Results_AC_s123456 G C0 Ts Cd F`**
(-3 if not done)