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

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

Exam simulation 2

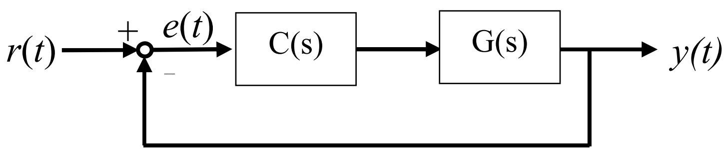
Part I (6 points)

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

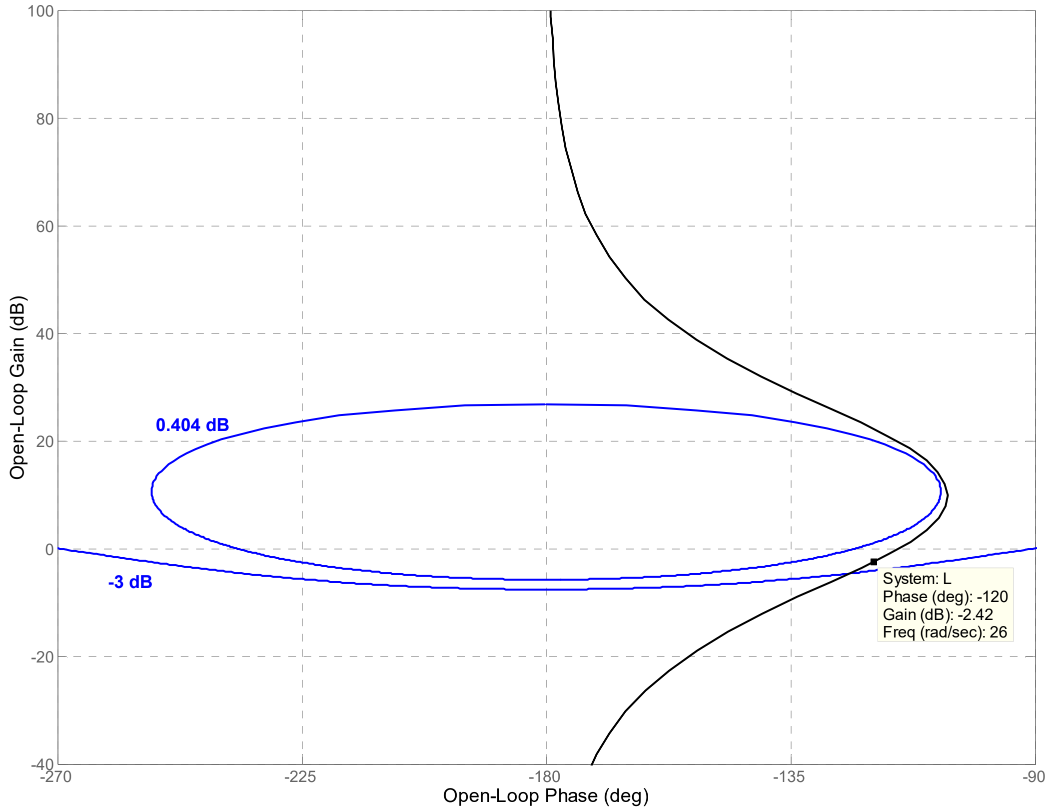
$$G(s) = \frac{1}{s(1-s/2)}.$$

Which of the following controllers does guarantee, besides closed loop stability, the steady state requirement $\left|e_r^\infty\right| \le 0.5$ for r(t) = 4 t ?

A) $C(s) = 8$.
B) $C(s) = 2$.
C) $C(s) = -8$.
D) None of the controllers of the other answers guarantees the given requirements.

Exercise 2

Consider the Nichols plot of the loop function L(s) of a stable unitary feedback control system reported in the figure below. The constant magnitude loci are referred to the complementary sensitivity function T(s). The point corresponding to the angular frequency 26 rad/s is reported too.



On the basis of the given Nichols plot, which of the following requirements are surely satisfied.

A) $T_p \leq 0.404$ dB, $\omega_b \leq 26$ rad/s and $\left|e_r^\infty\right| = 0$ for a ramp reference.

B) $T_p \leq 0.404$ dB, $\omega_b \geq 26$ rad/s and $\left|e_r^\infty\right| = 0$ for a step reference.

C) $\hat{S} \leq 10$ %, $\omega_c \leq 26$ rad/s and $\left|e_r^\infty\right| = 0$ for a ramp reference.

D) More than one among the other reported answers is correct.

Part II (10 points)

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

1 - Show that a unitary feedback control system with cascade controller is not BIBO stable if the loop transfer function $L(s) = C(s)G(s)$ is such that $L(j\omega) = -1$ for some ω.

2 – Consider a second order prototype system with an additional real negative zero ω_z described by the following transfer function

$$H(s) = \frac{1 - \dfrac{s}{\omega_z}}{1 + \dfrac{2\zeta}{\omega_n} s + \dfrac{s^2}{\omega_n^2}}, \omega_z < 0.$$

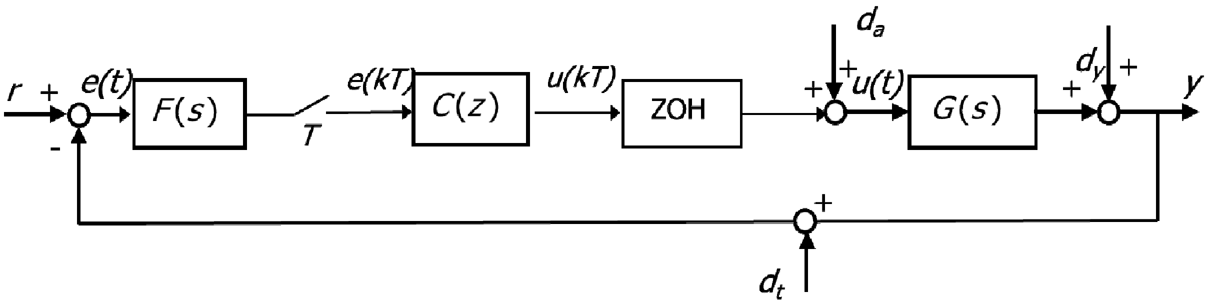
Discuss the effects of such real negative zero on the system step response with respect to a standard second order prototype system of the form

$$H(s) = \frac{1}{1 + \dfrac{2\zeta}{\omega_n} s + \dfrac{s^2}{\omega_n^2}}.$$

Support your answer with adequate motivations and, possibly, with numeric examples.

Part III (17 points)

Consider the feedback control structure below.



where

$$G(s) = -\frac{120}{s^3 + 15.8s^2 + 12s} \quad d_a(t) = \delta_a \varepsilon(t), |\delta_a| \le 0.4 \quad d_t(t) = \delta_t \sin(\omega_t t), |\delta_t| \le 1, \ \omega_t \ge 100 \,\text{rad/s}$$

Assume a sampling time $T_s = 0.015$ s, design a digital controller *C*(*z*) in order to meet the following requirements

- $|y_{d_a}^{\infty}| \le 0.5$
- $|y_{d_t}^{\infty}| \le 0.8 \cdot 10^{-2}$
- $\hat{S} \le 18\%$;
- $t_r \le 0.25$ s
- $\max_t|u(t)| \le 55$ in the presence of a unitary step reference

At the end of the design supposing that

$$d_y(t) = 0.2\sin(0.07t), r(t) = \varepsilon(t)$$

Evaluate through simulation the maximum amplitude of the controlled output $y(t)$.

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 $C_{SS}(s)=\dfrac{K_c}{s^h}, K_c = ..., h = ...$

$C_{SS}(s) =$

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**)
$\omega_h =$ $\gamma =$ $\omega_f =$ $n =$

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%)

- $\left| y_{d_a}^{\infty} \right| =$
- $\left| y_{d_t}^{\infty} \right| =$
- $\hat{S} =$
- $t_r =$
- $\max_t |u(t)| =$ in the presence of a step reference signal with amplitude 1

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)