AUTOMATIC CONTROL

Computer Engineering, Electronic and Communications Engineering

Laboratory practice n. 3

Objectives: Steady state behaviour, step response of prototype models.

Problem 1 (steady state properties of LTI systems)
Given the LTI system described by the following transfer below.

$$H(s) = \frac{1}{s^3 + 2s^2 + 5.25s + 4.25}$$

1. Compute, if possible, the steady state output response $y_{ss}(t)$ in the presence of the following input

$$u(t) = \left(3\sin(0.1t) + 2\right)\varepsilon(t)$$

2. Compute, if possible, the maximum amplitude of a sinusoidal input of the form

$$u(t) = A_u \sin(3t)\varepsilon(t)$$

so that, at steady state, the maximum output amplitude satisfies $| y_{ss}(t) | < 1$.
(Answer: 1. $y_{ss}(t) = (0.7038 \sin(0.1t - 0.1232) + 0.4706)\, \varepsilon(t)$ 2. $|A_u| \leq 17.7658$)

Problem 2 (step response of 2nd order systems)

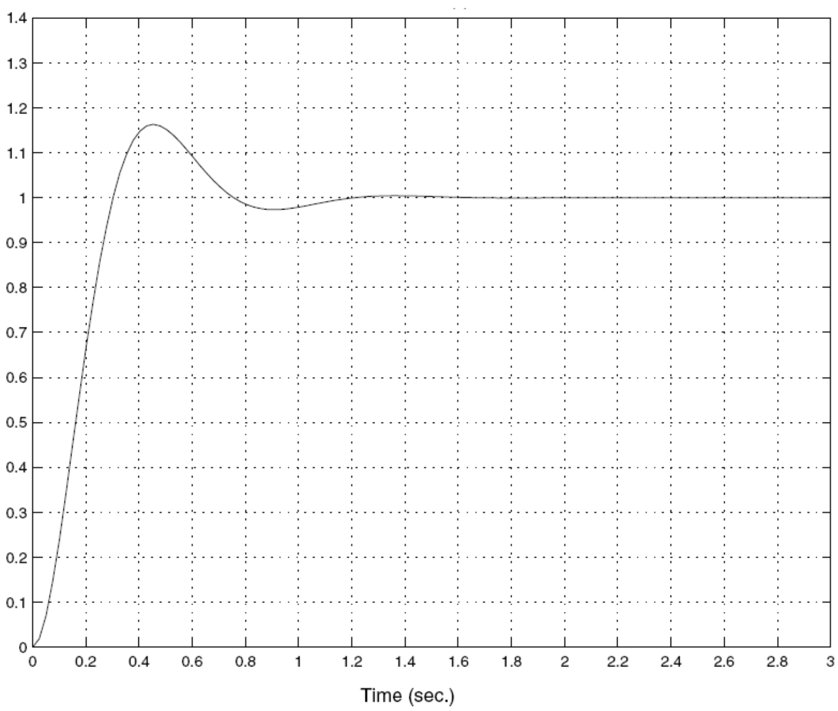
Consider the following 2nd order system transfer functions

$$H(s) = \frac{10}{s^2 + 1.6s + 4}$$

- Evaluate the natural frequency ω_n, the damping coefficient ζ and the time constant τ of the poles.
- Define H(s) in the MatLab environment and use the statement `step(H)` (see the online help for more details) to plot the unit step output response and, on the basis of the obtained plot, evaluate
  - Steady state value y_∞;
  - Maximum overshoot $\hat{s}$ and peak time $\hat{t}$;
  - Rise time t_r;
  - 5% settling time $t_{s,5\%}$.

(Answer: $\omega_n = 2, \zeta = 0.4, \tau = 1.25$ s, $y_\infty = 2.5, \hat{s} = 25.38\%, \hat{t} \simeq 1.715\,s, t_r \simeq 1.08\,s, t_{s,5\%} \simeq 3.8\,s$)

Problem 3 (step response of 2nd order systems)
The (zero state) output response in the presence of a step of amplitude 5 of an LTI system is reported in the picture below.



Compute the values of the parameters K, ω_n and ζ of a second order transfer function $H(s)$ of the form:

$$H(s) = K\frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

whose step response matches the given time course.

(Answer: $K = 0.2, \omega_n = 8, \zeta = 0.5 \rightarrow H(s) = \dfrac{12.8}{s^2 + 8s + 64}$)

Problem 4 (graphical representation of the frequency response function)
Consider the following transfer functions

1. $L(s) = \dfrac{5}{s^3}$
2. $L(s) = \dfrac{0.25}{s^2(1-0.5s)^2}$
3. $L(s) = \dfrac{s-1}{s(s^2-9)}$
4. $L(s) = \dfrac{1+0.5s}{(1+s)(1-s)^2}$
5. $L(s) = \dfrac{s^2+1}{(s^2-4)(s+4)}$

for eachplot the Bode diagrams using the MatLab statement `bode` and check the correctness of each plot based on the zeros and poles properties (may be also helpful to draw the asymptotic diagrams by hand). Take into account that the `bode` statement may add +/- 360° when computes the phase values… Then, draw (by hand) the polar and the Nyquist plots (check the results using MatLab); plot (using MatLab) the Nichols diagram.