Course of
"Automatic Control Systems"
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Problems

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✧ *Compute the analytic expression of the step response of the following LTI systems:*

- $G_1(s) = \frac{s+10}{s^2+6s+5}$; $G_2(s) = \frac{s+20}{s^2+s+1}$; $G_3(s) = \frac{-3(s-2)}{(s^2+4s+3)}$;
- $G_4(s) = \frac{s+14}{s^2+10s+30}$; $G_5(s) = \frac{s+24}{s^2+3s+45}$; $G_6(s) = \frac{s+15}{s^2+9s+20}$

✧ *Plot the step response for the different LTI systems*

Problem 1.b

✧ ***Compute the transfer function of the following LTI system:***

$$\dot{x} = \begin{pmatrix} 0 & 1 \\ \boldsymbol{a} & -1 \end{pmatrix} x + \begin{pmatrix} 0 \\ 1 \end{pmatrix} u \,,$$

$$y = \begin{pmatrix} 1 & 0 \end{pmatrix} x$$

✧ ***Discuss the stability by varying*** $a \in (-\infty, +\infty)$.

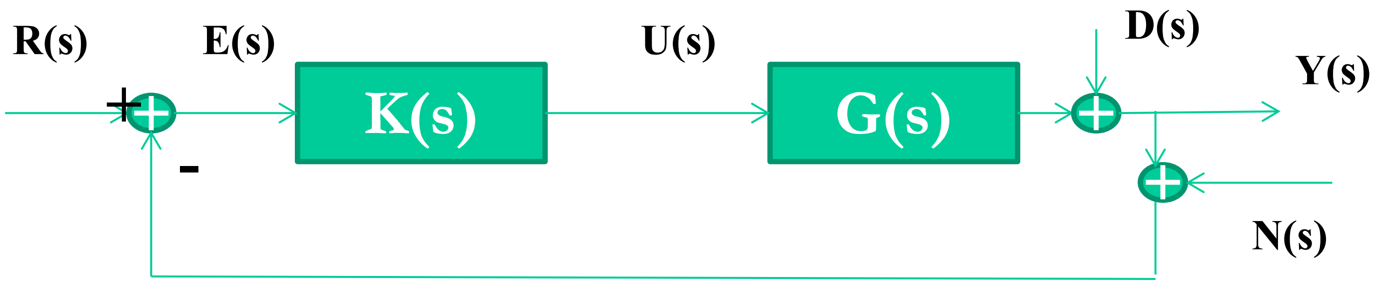
✧ ***Plot the step response for the LTI system with a = -4.***

Problem 2

✧ ***Study the frequency response of the following LTI systems by drawing the asymptotic Bode diagrams:***

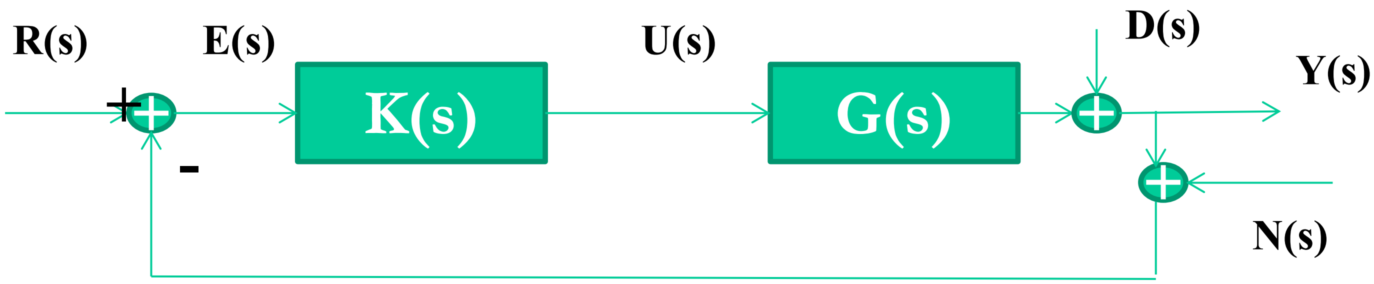
- $G_1(s) = \frac{s}{s^2+6s+5}$
- $G_2(s) = \frac{s}{s^2+s+1}$
- $G_3(s) = \frac{20(s+0.1)}{(s^2+21s+20)}$
- $G_4(s) = \frac{10(s+3)}{(s+1/3)(s+9)}$
- $G_5(s) = \frac{10(s+3)}{s(s+1/3)(s+9)}$

Problem 3 - Controller design



- *Stability*
- *Robust stability*
- *Steady-state performances*
- *Transient performances*

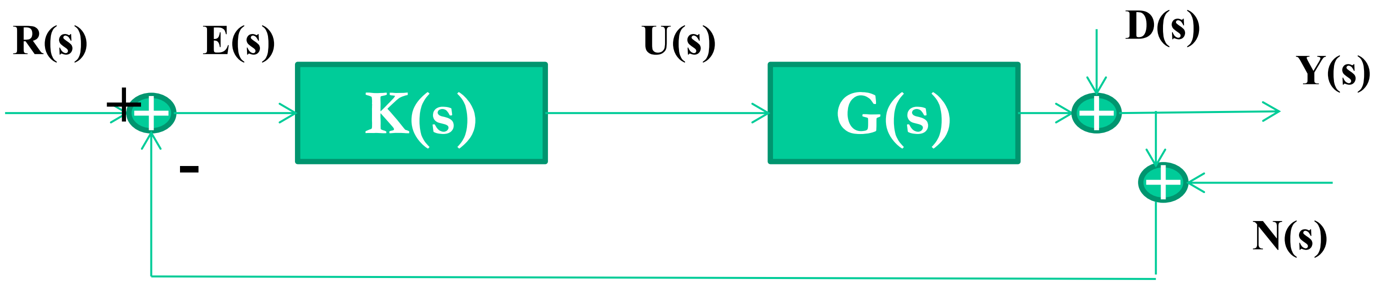
Problem 3 – Example 1



$$G(s) = \frac{1}{s^2+s+1}$$

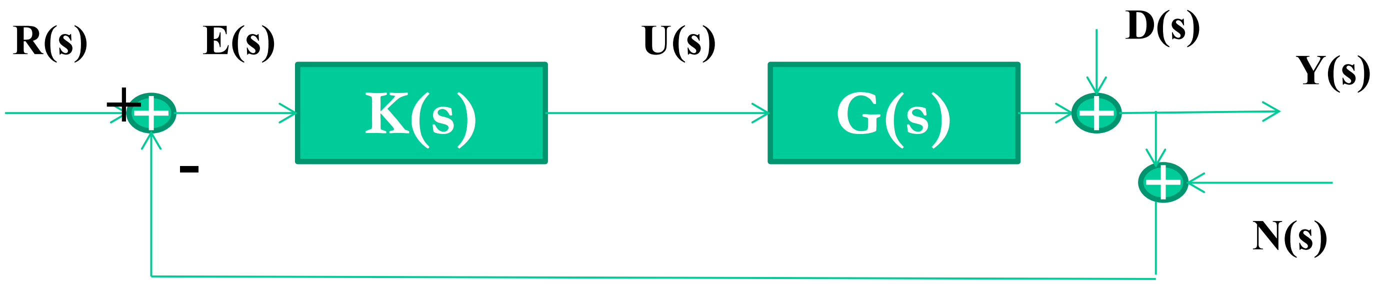
- $e_{\infty r} \leq 10\%$ for a reference signal $r(t) = r_0 1(t)$
- Overshoot $s \leq 30\%$
- Settling time $t_{s5\%} \leq 1s$

Problem 3 – Example 2



$$G(s) = \frac{1}{s^2+s+1}$$

- $e_\infty = 0$ for a reference signal $r(t) = r_0 1(t)$
- Overshoot $s \leq 30\%$
- Settling time $t_{s5\%} \leq 2s$



$$G(s) = \frac{4}{(s+4)(s+2)}$$

1. Devise a controller $K(s)$ with the aim to satisfy the following requirements:
   - $e_{\infty,r} < 10\%$ for a reference signal $r(t) = r_0 1(t)$;
   - overshoot $s \leq 30\%$.
2. Compute the gain and phase margins of the open loop function for $K(s)$ devised at 1).
3. Plot the resulting step response of the closed loop system.