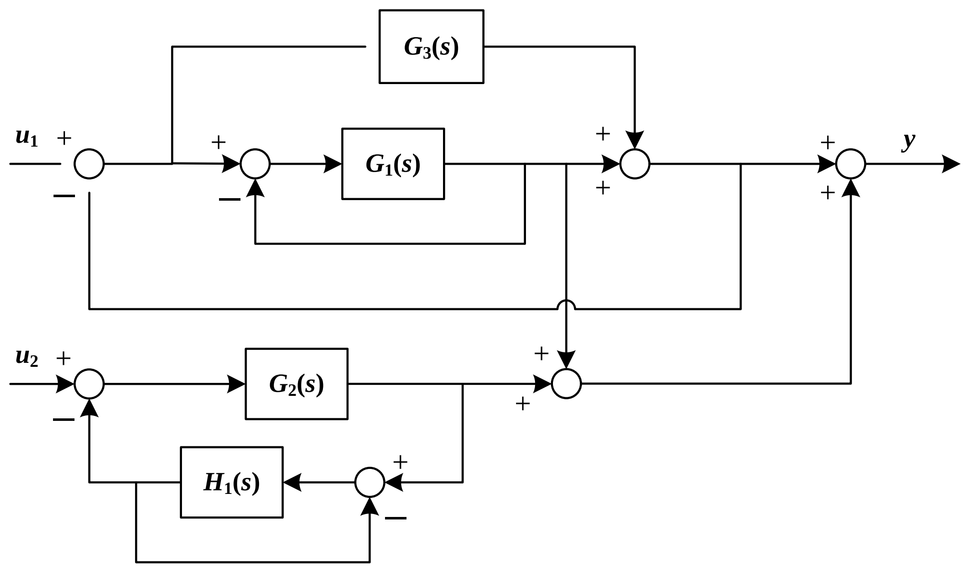
Elektrijada 2008.

Problems for the competition in the area of CONTROL SYSTEMS

1. Block diagram of the control system is given in the figure:



a) Using Mason's rule, obtain transfer function row matrix from the input $u = [u_1\ u_2]^T$ to the output y.

b) For the given transfer functions: $G_1(s) = \dfrac{1}{s+1}$, $G_2(s) = \dfrac{1}{s+3}$, $G_3(s) = 10$ and $H_1(s) = K$, obtain the range of the parameter K which stabilizes the system.

2. System is given by the state-space model:

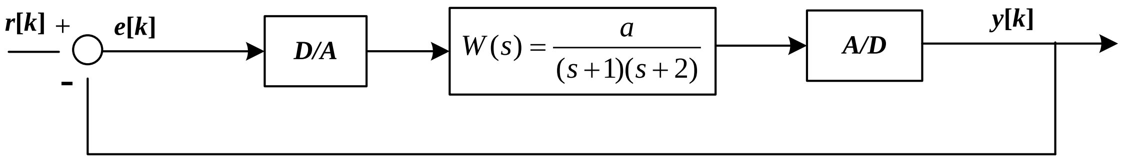
$$\dot{\mathbf{x}} = \mathbf{A}\mathbf{x} + \mathbf{B}u,\quad y = \mathbf{C}\mathbf{x},\quad \mathbf{A} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -10 & -5 \end{bmatrix},\quad \mathbf{B} = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix},\quad \mathbf{C} = \begin{bmatrix} 12 & 0 & 0 \end{bmatrix}.$$

a) Draw the structure of the full-state observer (estimator).

b) Sketch the frequency characteristics of the system and obtain the unity gain frequency and the phase margin.

c) At the output y measurement there exist the high frequency measurement noise n, starting from frequency ω_{0n} = 4 rad/s. Design the full-state observer (obtain the observer gain matrix **G**), so the state observation is performed as good as possible, while the measurement noise is suppressed as much as possible.

3. Control system is given in the figure:



The combination of applied digital/analog D/A and analog/digital A/D conversion is modeled as the zero-order hold and the ideal sampling. Sampling period is $T = \ln 2$ sec.

a) Obtain the discrete open-loop transfer function $W(z) = Y(z) / E(z)$ and, applying the Jury criterion, obtain the range of the parameter a which stabilizes the closed-loop system.

b) Obtain the value of the parameter a, which minimizes the stationary value of the reference tracking for the step reference. What is the value $e[k\to\infty]$ of that error?

c) If the value of the parameter is $a = 0.1$, obtain the impulse response $g[k]$ of the closed-loop system, find its maximal value $g_{\max}$ and the sample $k_{\max}$ at which this maximum takes place.

d) On the basis of the impulse response $g[k]$ of the closed-loop system for $a = 0.1$ and the position $k_{\max}$ of the sample at which maximum $g_{\max}$ takes place, from the previous point c), independent new systems S_1 and S_2 are formed, which impulse responses are:

$$S_1:\ g_1[k] = g[k]\cdot\left(h[k] - h[k-(k_{\max}+1)]\right)$$
$$S_2:\ g_2[k] = g[k]\cdot h[k-(k_{\max}+1)].$$

Input $r[k]$ is independently applied to systems S_1 and S_2 and the following responses are obtained: $y_1[k]$ for the system S_1 and $y_2[k]$ for the system S_2. Obtain the response $y[k]$ of the original closed-loop system for the input $r[k]$ applied.