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Problems for the competition in the area of CONTROL SYSTEMS

1. For the digital system, given by its state-space model:

$$x[k+1]=\begin{bmatrix}0.2 & -0.7\\ 0 & 1\end{bmatrix}x[k]+\begin{bmatrix}1 & -1\\ 0 & 1\end{bmatrix}u[k]$$
$$y[k]=\begin{bmatrix}1 & a\end{bmatrix}x[k]$$

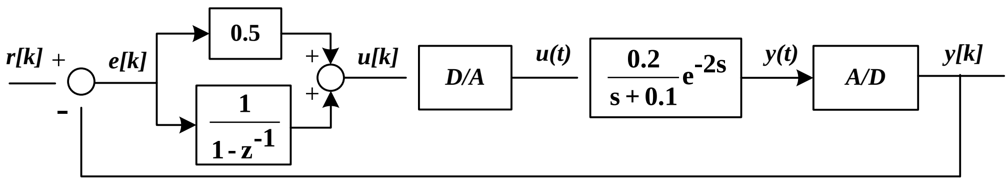
a) Discuss controlability and opservability of the states with respect to real parameter *a*.

b) The goal is to take the system from the initial state $x[0] = [-1\ 1]^T$ to the desired state $x^* = [1\ -1]^T$. Determine the minimal number of control signal samples *N* and values of the control signal $u[0]$, ..., $u[N\text{-}1]$, which will make the desired transition.

c) Sketch the root locus of given digital system regarding the parameter $a \in [0, \infty)$.

d) If the sampling period is T = 0.2sec, close the state-feedback to make the closed-loop system behave as oscillator with analog frequency ω_{osc} = 2 rad/s.

2. Digital computer controls the process in configuration presented in figure:



Applied combination of digital/analog D/A and analog/digital A/D conversion is modeled as zero order hold circuit. Sampling period is T = 1sec.

a) Obtain the open-loop transfer function $W(z) = Y(z) / E(z)$.

b) Obtain the closed-loop transfer function $T(z) = Y(z) / R(z)$ and values of the first five samples of the closed-loop impulse response.

c) Determine the stability of the closed-loop system.

3. The system open-loop transfer function is $W(s)=K\dfrac{s-1}{s(s+1)(s^2+10s+225)}$.

a) If the gain is K = 1125, sketch the amplitude and phase frequency characteristics and obtain the phase margin Φ_{pf} and gain margin *d*.

b) If the gain is K = 1125, determine the bandwidth ω_0 of the closed-loop system.

c) Using the Nyquist criterion, determine the range of gain values K that stabilize the closed-loop system.