Computer Controlled Systems

2nd midterm test

December 7, 2017

theoretical questions (25 points)

(The answers can be given in Hungarian)

1. Give the transfer function of a continuous time PID controller. What are the parameters of the controller? Draw the block scheme of a complete PID control loop, where a system with transfer function $G(s)$ is controlled. (5p)

2. What is the task of a state observer? Give the equations of a state observer for a continuous time LTI system given by the matrices (A, B, C). What are the known data, and what is to be computed and how? What are the input and output of a state observer? (5p)

3. Describe briefly the linear quadratic (LQR) control problem and its solution (objective function, design parameters, type of the obtained feedback, properties of the closed loop system). (No detailed computations or proofs are necessary.) (5p)

4. Give the general form of state space models for discrete time LTI systems with the dimensions of vectors and matrices. How do the matrices of the discrete time model depend on the (A, B, C) matrices of the continuous time model, if the sampling time is h and zero order hold is applied at the input? (5p)

5. Consider the following transfer function

$$H(s) = \frac{s^2 + 2s + 1}{s^4 + 2s^3 + as^2 - 3s + 1},$$

   where $a \in \mathbb{R}$.

   (a) Is there any choice of a such that $H(s)$ is asymptotically stable? Why? (2p)

   (b) For any finite value of a, is it possible to asymptotically stabilize $H(s)$ by a linear output feedback $u = -ky$, where $k \in \mathbb{R}$ is appropriately selected? Why? (3p)

Computer Controlled Systems

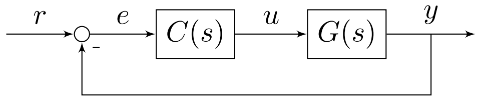
2nd midterm test

2017.12.07.

computational exercises (25 points)

(The answers can be given in Hungarian)

1. The following transfer function is given: $G(s) = \frac{s+2}{s-1}$. We want to design a PD controller with the transfer function $C(s) = K_P + sK_D$. Determine the values of K_P and K_D, such that the poles of the resulting controlled system are -1 and -5. Will the output y of the controlled system converge to any constant reference signal r? (5p)



2. Consider the following continuous-time state-space model:

$$A = \begin{pmatrix} 1 & 2 \\ 0 & -1 \end{pmatrix}, \quad B = \begin{pmatrix} 0 \\ 1 \end{pmatrix}, \quad C = \begin{pmatrix} 2 & 1 \end{pmatrix}$$

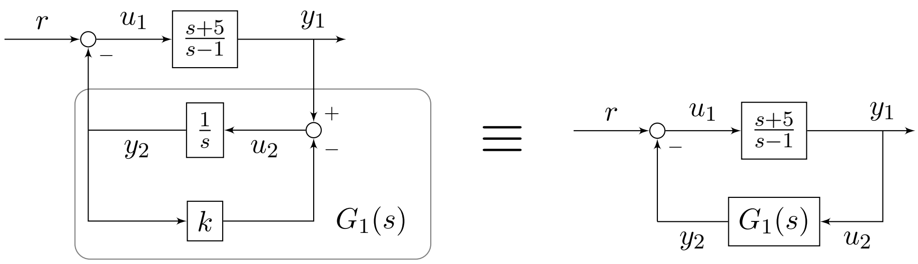
   a) Determine the model matrices Φ and Γ of the discrete time state-space model

   $$x(k+1) = \Phi x(k) + \Gamma u(k), \quad y(k) = Cx(k),$$

   if the sampling period is $h = \ln(2)$. (4p)

   b) Is the discrete-time state-space model stable? Justify your answer! (1p)

3. The following block diagram is given:



   a) Compute the resulting transfer function $G(s)$ for this block diagram. (4p)
   First of all try to determine the resulting transfer function $G_1(s)$ of the highlighted subsystem.

   b) Choose the value of k such that the poles of the resulting transfer function be -1 and -2. (1p)

4. Let us consider the following continuous time LTI system:

$$A = \begin{pmatrix} 8 & -1 \\ 1 & 6 \end{pmatrix}, \; B = \begin{pmatrix} 1 \\ 0 \end{pmatrix}, \; C = \begin{pmatrix} 1 & 0 \end{pmatrix}$$

   a) Check the asymptotic stability of the system. (1p)

   b) Design a pole-placement controller, for which the desired characteristic polynomial is $s^2 + 14s + 49$. (4p)

   c) Check the results by recomputing the poles of closed loop. (1p)

   d) Design a state observer with the following prescribed poles: $-2, -2$. (4p)