Indian Institute of Technology Madras
Mid semester Exam
ID6003 - AI in Process and Logistic optimization
Points: 20, Date: 26 October 2023

Instruction

1. It is an open-book exam, and the students are expected to follow the typical honor code of a take-home exam.

2. The students will not give or receive aid in the exam through any mode. The violation of the honor code will be reported to the authority.

3. If you have any doubts, please make appropriate assumptions to solve the problems and mention them in the answer sheet.

4. The students must submit the hand-written solutions and the details of each step to arrive at the final solutions. In addition, the students must submit their codes/simulink files to justify their answers, if any.

5. The codes/simulink files must be uploaded as a single zip file along with the scanned copy of the hand-written answer as a single PDF.

Problems

1. A waste-water treatment plant is interested in designing a controller for maintaining a certain level of feed in a storage tank by manipulating the inlet flow rate ($m^3 sec^{-1}$). You have been entrusted with the task of designing a controller for them. A step response data indicating the feed levels at different times (sec) has been given to you (Q1.xlsx).

   (a) Plot the data provided and comment on it. [1]

   (b) Design and simulate a PI controller (do not use the PID block in Simulink) for the above system using the transfer function

   $$\frac{1.5}{11.2s^2 + 2.028s + 1}$$

   [2]

   (c) Tune the designed controller using the ZN-tuning method and simulate the system. [2]

2. Hyalomeds pharmaceutical company is seeking your help in laying out a control plan for maintaining the temperature and the level of the fermentation broth in a fed-batch fermentor for producing a biomedically significant polymer. The intention is to manipulate the flow rate of the cooling water in the cooling jacket and the feed rate of the fresh carbon source using feedback loops and PID controllers.

   (a) What kind of control structure is the company seeking? [1]

   (b) Draw a blueprint as a block diagram to describe the feedback loops. [2]

   (c) Point out the type of balance principles in each loop. [1]

3. A client of yours provides an Open loop transfer function of a system for which an appropriate controller has to be designed.

$$\frac{1}{s(s+1)(s+4)}$$

   (a) Simulate the different controller configurations for decent control and report the observation for the above system. [3]

   (b) Choose an appropriate controller setting for your client and state why. [1]

4. A discrete system with sampling time of 10 time units has a step response coefficients as given below: $S = \begin{bmatrix} 0.0527 & 0.3712 & 0.7149 & 0.9004 & 0.9707 & 0.9924 & 0.9924 \end{bmatrix}$. This discrete system is subjected to a input profile, $u = \begin{bmatrix} 0 & 2.6942 & 0.1988 \end{bmatrix}$ with a zero order hold (zoh) with sampling time same as discrete system.

   (a) Find the free response [1] of the system up to 100 time units. [2]

   (b) Compute the controller move at time unit $= 30$ if the controller has to take the system to the setpoint of 1 (ysp $= 1$) at the 70th time unit with only one control move. [2]

   (c) Implement the controller move computed above and find the free response [2] of the system up to 100 time units. [2]

   (d) Report the sum of squared error between the setpoint (ysp $= 1$) and the free response (upto 100 time units) computed in (a) and (c). [1]

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[1]For free response, the input changes are assumed to be zero beyond the given input profile.
[2]For free response, the input changes beyond the computed move is zero.