INDIAN INSTITUTE OF TECHNOLOGY–KHARAGPUR

Mid-Spring Semester 2012-2013 (Closed Book)
Date: 22 February 2013

Course No.: CH 61016 *Max. Time*: 2 hrs
Course Title: Process Dynamics and Control *Total Marks*: 30

Answer all questions

[No need of separate answer script]

Q1. (a) Discuss the importance of *real* PID controller and compare this control scheme with its *ideal* counterpart.
(b) Derive the velocity form of PID controller that can avoid the derivative kick.
(c) Why the proportional gain (K_C) is varied in gain-scheduled PI controller and how is it varied? **[(1+1)+2+(1+1)=6]**

Q2. (a) Consider the following nonminimum phase system:

$$G_p = \frac{-9s+1}{(15s+1)(3s+1)}$$

Derive a feedback controller expression (stable) by using the direct synthesis approach.
(b) Discuss the steps involved in tuning the feedforward controller.
(c) Discuss the ratio control schemes with an example of chemical reactor, and their relative merit and demerit. **[4+2+3=9]**

Q3. (a) What is a control relevant model? Write different types of control relevant models.
(b) What are the possible methods of realizing state space model from transfer function model? Use any one method to realize state space model from transfer function model

$$g(s) = 12\,\frac{7s+1}{5s+1}\,e^{-3s}$$

(c) In order to troubleshoot a styrene polymerization reactor, the control engineer is required to find the controller parameters using the linear state space model. The dynamic model for this reactor is given below: What should be the linear state space model considering q_c and C_{mi} as the input variables and T and C_p as output variable. **[5+5+5]**

$$\frac{dc_m}{dt} = \frac{q_m c_{mi} - q_t c_m}{V_r} - k_p c_m C_p$$

$$\frac{dc_i}{dt} = \frac{q_i c_{if} - (q_m + q_i + q_s)c_i}{V_r} - k_d c_i$$

$$\frac{dc_s}{dt} = \frac{q_s c_{sf} + q_i c_{if} - q_t c_s}{V_r}$$

$$\frac{dT}{dt} = \frac{q_t (T_f - T)}{V_r} + \left(\frac{\Delta H_{rxn}}{\rho C}\right) k_p c_m C_p - \frac{UA(T - T_c)}{V_r \rho C}$$

$$\frac{dT_c}{dt} = \frac{q_c (T_f - T)}{V_c} + \frac{UA(T - T_c)}{V_c \rho_c C_c}$$

$$C_p = \sqrt{\frac{2fk_d c_i}{k_{tc} + k_{td}}}$$

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