INDIAN INSTITUTE OF TECHNOLOGY–KHARAGPUR

End-Autumn Semester 2012-13 (closed book)

Course No.: CH 31011   **Max. Time**: 3 hrs

Course Title: Instrumentation and Process Control   **Total Marks**: 50

Answer all questions

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1. (a) Why is it impossible for two first-order noninteracting capacities in series to exhibit underdamped behavior? **[3]**

   (b) What are the relative advantages and disadvantages of the two time-integral criteria, IAE and ITAE? How would you select the most appropriate for a particular application? **[1+1]**

   (c) Consider the following characteristic equation:

   $$s^4 + ks^3 + s^2 + s + 1 = 0$$ **[3]**

   Determine the range of k for stability.

2. (a) Do the stability characteristics of a process change with feedforward control as they do with feedback? Elaborate on your answer. **[3]**

   (b) What value of gain margin is recommended in Z-N method for proportional control alone? How? **[1+1]**

   (c) Show that the reciprocal of the first-order system time constant is referred to as the *corner frequency*. **[3]**

   (d) A first-order process with dead time has the transfer function

   $$G_p(s) = \frac{5\,e^{-t_d s}}{s+1}$$ **[4]**

   This process is to be controlled with a PI controller. Use the Bode stability criterion to find the range of values for the gain K_c as a function of t_d so that the closed loop response is stable. Assume that $G_m = G_f = 1$ and that the integral time constant $\tau_I = 0.25$ min.

3. (a) Discuss the rationale behind an override control system. What situations is it called upon to control? Discuss its operating features with an example. **[1+1+3]**

   (b) What is our goal when designing a controller for a system with inverse response? Describe what an inverse response compensator does. **[1+4]**

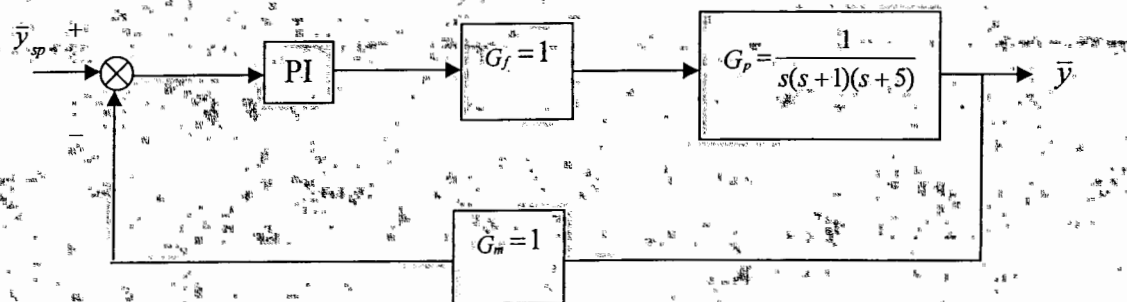   (c) Consider a closed-loop process shown in Fig. 1 in which a PI controller is used to control the system.

Fig. 1. A closed-loop process with PI controller

(i) Find the ultimate gain (K_u) and ultimate period (P_u).　　　　　　　　　[(2.5+2.5)+2]

(ii) Use the Tyreus – Luyben recommended settings and tune the PI controller.

4. (a) Describe with a diagram the construction and working principle of a flapper/nozzle system. Explain the use of a flapper/nozzle system for a current-to-pressure (I/P) converter.　　　　　　　　　[3]

(b) How are various pressure-measuring instruments classified? Describe with a diagram the construction and working principle of any instrument for measurement of high vacuum.　　　　　　　　　[4]

(c) What are the possible sources of errors in filled-in thermometers? How are these errors minimized or compensated for?　　　　　　　　　[4]

(d) Why does self-heating cause a problem with RTDs? Why is it of lesser importance with thermistors?　　　　　　　　　[2]