

INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

End-Spring Semester 2022-23 (closed book)

Course No.: CH21208

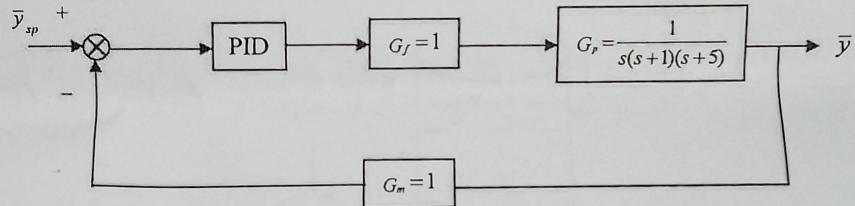
Course Title: Instrumentation and Process Control

Max. Time: 3 hrs

Total Marks: 50

Answer all questions

- Q1.** (a) What is derivative kick? Is there any way to overcome this problem in the feedback controller? [2+2+2+(2+2+2)=12]
 (b) Find the amplitude ratio (AR) and phase angle (ϕ) for the PID controller.
 (c) What are the major limitations of Ziegler-Nichols tuning method?
 (d) Consider a closed-loop process shown in Fig. 1, in which a PID controller is used to control the system.

**Fig. 1.** A closed-loop process with PID controller.

- (i) Find the ultimate gain (K_u) and ultimate period (P_u).
 (ii) Use the Tyreus – Luyben recommended settings and tune the PID controller.
 (iii) Find the pole(s) and zero(s) of the PID controller.
- Q2** (a) Show for the following system that the AR of $G_{OL}(s)$ equals unity at cross over frequency provides oscillations in output (y) with constant amplitude: [3+3+1+3=10]

$$G_p(s) = \frac{e^{-0.123s}}{0.1s+1} \quad G_c = K_c \quad G_f = G_m = 1$$

- (b) Investigate the stability of a closed-loop system whose characteristic equation has the following form:

$$8s^3 + 6s + 3 = 0$$

- (c) What is the basic difference between the cascade and the feedforward-feedback combined control scheme in terms of their application?

- (d) The transfer functions of a process with respect to manipulated variable and disturbance are given, respectively, as:

$$G_p = \frac{K_p}{(\tau_1 s + 1)(\tau_2 s + 1)} \quad G_d = \frac{K_d}{(\tau_3 s + 1)}$$

Design the feedforward controller that is physically realizable.

- Q3.** (a) Consider a liquid tank system shown in Fig. 2. The liquid level should be maintained above height h_2 to avoid cavitation at the pump.
 (i) Develop the override control scheme.
 (ii) Mention the action (direct/reverse) of the controllers. $[(2+2+2)+2 = 8]$
 (iii) Explain how the override controller works when the level is at h_1 .

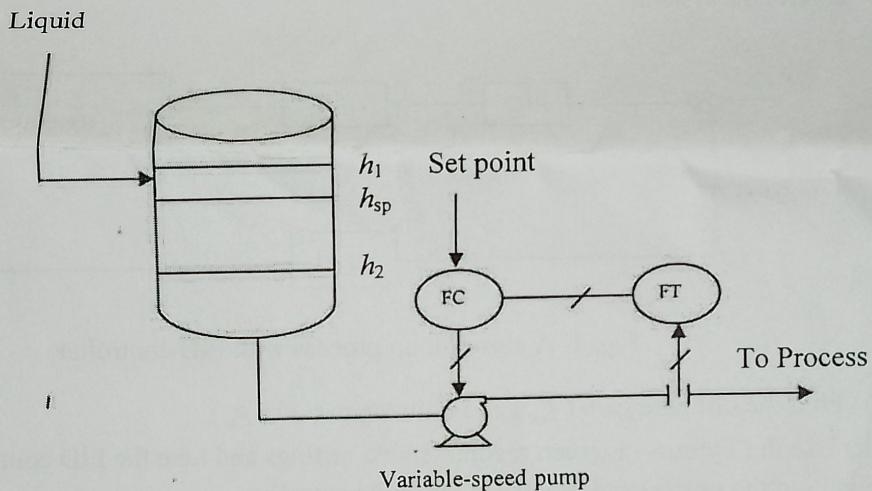


Fig. 2. The liquid tank under flow control.

- (b) Discuss a suitable control scheme used to keep the ratio of fuel/air fed to a combustion chamber at its optimum value.

- Q4** (a) What is the difference between a variable conversion element and variable manipulation element?

Give examples. [1.5]

- (b) What is the difference between an active and passive transducer? Give example for both kind. [1.5]

- (c) What is the difference between null and deflection mode of measurement? Discuss the relative merits and demerits of these two methods with examples. [1.5]

- (d) What are spurious inputs? What are different kinds of spurious inputs usually present? Give examples. [1.5]

- Q5** (a) Sketch a flapper nozzle system and explain how it converts a displacement signal into a pneumatic signal. [2]
(b) Sketch a control valve and identify various parts of the control valve and actuator. [1.5]
(c) What is the difference between a fail open and a fail close control valve? Describe a situation where you will use a fail open control valve and another situation where you will use a fail close control valve. [1.5]
(d) What is inherent control valve characteristics and installed characteristics? Sketch various commonly encountered inherent control valve characteristics. [2]

- Q6** (a) Crude oil is flowing through a pipeline of 1 m dia. What type of flowmeter is most suitable here? Justify your answer. [1]
(b) A highly viscous polymeric fluid which has large number of small trapped gas bubbles is flowing through a circular tube at a very low rate. How to obtain the flow rate of such a flow? [1]
(c) What is reference junction correction? Discuss relative merits and demerits of thermocouple and thermistors. [2]
(d) Draw symbols for process lines, pneumatic lines, safety relief valve and needle valve. How to determine if an instrument is field mounted, panel mounted or DCS display? [2]
(e) Discuss two different level monitoring methods. [1]

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