B.E/SEM VII (CBSGS)

Paper / Subject Code: 42701 / Industrial Process Control

May 2019.

(3 Hours)

[Total Marks: 80]

N.B: (1) Question No.1 is **compulsory.**
(2) Answer any **three** questions from Question Nos. 2 to 6.
(3) Assume suitable data if necessary.

1 Answer any FOUR of the following questions:-
(a) Explain crystallization curve. 5
(b) Explain the need of multi effect evaporators. 5
(c) Discuss control parameters in gas turbine. 5
(d) What do you mean by runway reaction? 5
(e) Explain hazard triangle. 5

2 (a) Draw surge characteristics. Explain any one method of surge control for centrifugal compressor. 10
(b) Explain the construction and working of 1:1 shell and tube heat exchanger. 10

3 (a) Draw and explain process flow diagram of refinery industry. 10
(b) Discuss feedback and cascade control scheme of evaporator. 10

4 (a) What is start up heater? Discuss its process and safety control. 10
(b) Explain atmospheric tray control scheme with safety interlocks. 10

5 (a) Explain the process of Penicillin-G production along with its control parameters. 10
(b) Discuss pressure control scheme and overhead product composition of distillation column. 10

6 Write short note- 20
(a) Shrinking and swelling effect in boiler
(b) Hazard reduction techniques.

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Duration: 3 Hours Max. Marks 80

N.B.

1. **Q.1** is compulsory. Attempt **any three** from the remaining questions.
2. All questions carry equal marks.
3. Figures in the Right margin indicate full marks.
3. Assume suitable data if necessary

Q.1 Attempt **any four**

a. Determine the sign-definiteness of following matrices **20**

$$\text{(i) } F = \begin{bmatrix} 3 & 2 \\ 1 & 1 \end{bmatrix}, \quad \text{(ii) } G = \begin{bmatrix} -1 & -2 \\ -3 & -2 \end{bmatrix}$$

b. Define the singular point in phase-plane. Compute the singular points for the following system.

$$\dot{x} = x^3 - 3x^2 + 2x$$

c. Define relative degree for the system $\dot{z} = f(z) + g(z)u$ at $y = h(z)$.

d. Linearize the following system at point $z_o = [-1\ 1\ 1]^T$ with the nominal input is to be held constant at $u_0 = 1$.

$$\begin{aligned} \dot{z}_1 &= 0.5z_2^2 - 0.5 \\ \dot{z}_2 &= 0.5z_3^2 - 0.5 \\ \dot{z}_3 &= -3z_1 - z_2^2 - z_3^2 + u \end{aligned}$$

e. Obtain the classical control '**c**' from the IMC controller '**q**' using block diagram reduction rules.

f. Explain the linear and nonlinear components of the friction.

Q.2 A. Write the steps to construct the Lyapunov function using variable gradient method. **10**

B. Obtain the describing function for saturation nonlinearity. **10**

Q.3 A. Determine the stability of the system, **10**

$$\begin{aligned}\dot{x}_1 &= -2x_1\\ \dot{x}_2 &= -3x_2\end{aligned}$$

using Lyapunov's equation.

B. Linearize the following system using feedback control **10**

$$\begin{aligned}\dot{x}_1 &= -x_1 - x_2^2 + (\sin x_1 + \cos x_1)u\\ \dot{x}_2 &= x_1\\ y &= x_2\end{aligned}$$

Where y is output and u is input.

Q.4 A. What is limit cycle? Explain it with Vander Pol's equation. **10**

B. What is jump resonance in frequency response? Explain it with an example. **10**

Q.5 A. Construct the phase trajectory for the system $\ddot{x} + \dot{x} + 2x = 0$ using delta method. Consider an initial condition $x(0) = 1,\ \dot{x}(0) = 1$. **10**

B. Design the optimal control for the system **10**

$$\dot{x} = \begin{bmatrix}1 & 0\\ 0 & -1\end{bmatrix} x + \begin{bmatrix}1\\ 1\end{bmatrix} u$$

that minimizes the performance index

$$J = \frac{1}{2}\int_0^\infty \left\{ x^\top \begin{bmatrix}1 & 0\\ 0 & 1\end{bmatrix} x + u^2 \right\} dt$$

Q.6 A. Design the IMC controller for the system model **10**

$$\tilde{G}_p = \frac{e^{-3s}(-0.5s+1)}{25s+1}$$

to track the step input. Use simple factorization for design.

B. Obtain the IMC based PI controller for the model **10**

$$\tilde{G}_p = \frac{5}{10s+1}$$

(3 Hours) [Total Marks: 80]

N.B: (1) Question No. **1** is compulsory.
(2) Attempt any **Three** questions from remaining.
(3) Figures to the right indicate full marks.

1. Answer the following: - [20]
   a) Explain the different types of plants and controls with examples.
   b) Draw a ladder diagram for a Two – Motor system having following conditions: -
      i) Starting push button starts Motor-1.
      ii) After 10 seconds, Motor-2 is ON.
      iii) Stopping the switch stops Motor -1 and 2.
   c) List any three SCADA vendors with their system.
   d) Explain the duties and tasks of level 4 in hierarchical computer control.

2. a) Design a PLC based automation system for Oven with the following sequence of operation: - [10]
   i) Heater will be ON, when the power switch is activated and door is closed and temperature is below the limit.
   ii) The fan will be ON when the temperature is above the limit and door is closed.
   iii) The light will be ON, if the light switch is ON or whenever the door is open.
   Draw the GUI and I/O wiring diagrams. Also show memory calculations.
   b) Explain sinking and sourcing output modules of PLC with neat diagram. [10]

3. a) Explain with block neat diagram, Centralized control system architecture. [10]
   b) Explain the functions and task of supervisory computer in DCS. [10]

4. a) Explain how SCADA is used for a geographically large area with diagram. [10]
   b) Explain with neat diagram, a system that allows an MTU to store data in central data store. [10]

5. a) What are the safety standards? Explain IEC 61508 seven-part standard in detail. [10]
   b) What is an Alarm, categories of Alarm, objectives of good Alarm and factor to be considered in the design of Alarm? [10]

6. Write note on: - **(Any Two)** [20]
   a) ERP and typical modules of ERP.
   b) Advanced PLC instructions.
   c) Evolution of DCS.

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