Ref No: **Ex/EE/PC/B/T/412/2024(S)**

B. E. ELECTRICAL ENGINEERING 4TH YEAR 1ST SEMESTER SUPPLEMENTARY EXAMINATION, 2024

SUBJECT: - PROCESS INSTRUMENTATION AND CONTROL

Full Marks 100

Time: Three hours **Part-I** **(50 marks for each part)**✓

Use a separate Answer-Script for each part

Answer Any Three Questions

Two marks reserved for neat and well organized answers

Q.1a). Describe the main components of a process control loop. Differentiate between servo problem and regulatory problem. What are the popular electrical and pneumatic signal transmission standards employed in industrial process control? 08

Q.1b). Why and how are provisions for (*i*) bias term and (*ii*) anti-derivative kick features provided in process controllers? 08

Q.2a). How can an electronic *PID* controller be designed in parallel form employing four op-amps? Derive its transfer function. How can a similar electronic *PID* controller circuit be designed using three op-amps? 08

Q.2b). Describe in detail how can a pneumatic *PI* controller be designed using a baffle-nozzle arrangement and feedback bellows? Derive its transfer function. State any assumptions made and justify those assumptions. 08

Q.3a). Describe the roles of DAC and ADC in a process control loop involving a digital controller. Describe in detail the realization of a digital PD controller using backward difference algorithm. 08

Q.3b). Explain in detail how can hard and soft switching schemes be employed for anti-integral windup purposes in process control? 08

Q.4a). Derive the transfer function of a time delay element. For a first order process with time delay, controlled by a *P* controller, show using Bode plot how the overall performance varies with increase in time delay. 08

Q.4b). Explain in detail how can an electro-pneumatic actuator be designed using electro-pneumatic converters. Hence derive its input-output relation and state any assumptions made. 08

Q.5. Write short notes on any **two**: 08+08

(a) Direct-acting and reverse-acting relay valves.

(b) Smith's controller for time delay systems.

(c) Piston type and motor type pneumatic actuators.

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Part II (50 marks)

Question 1 is compulsory

Answer ***Any Two*** questions from the rest (2×20)

Question No.			Marks
Q1	Answer ***any Two*** of the following:		
	(a)	Define, with the help of a schematic diagram, the following terms associated with a closed-loop process control system: (i) Controlled Variable, (ii) Actuating Signal, (iii) Manipulated Variable.	5
	(b)	Describe "Lumped-parameter" and "Distributed Parameter" models with suitable examples.	5
	(c)	Why PID controller is called a "Gain-Reset-Preact Controller"?	5
	(d)	What is feed-forward control? How is it different from feedback control?	5
Q2	(a)	What is *Process Time Lag?* What are the main factors responsible for it?	2+4
	(b)	What are "Integral Balance" and "Instantaneous Balance" techniques of process modeling? Obtain the model of a "Liquid Surge Tank" using both the methods.	2+4
	(c)	Figure Q2(c) shows a schematic diagram of the Lube Oil Cooler and associated temperature control scheme. Obtain the block diagram for the closed-loop control scheme and show the various signals and variables associated with it.	8

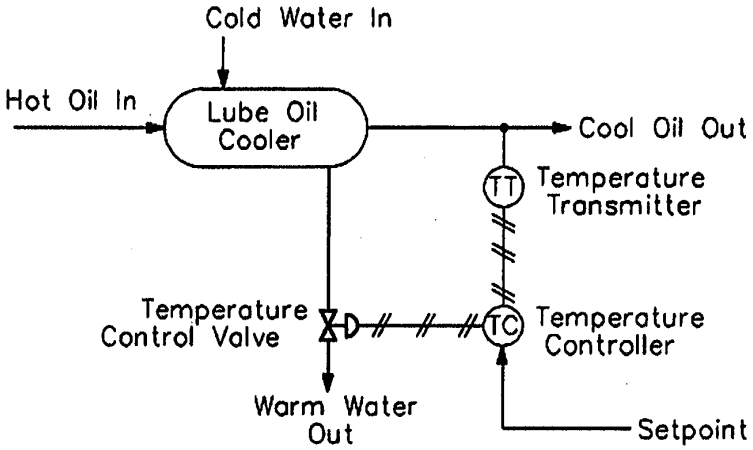

Figure Q2(c)

Q3	(a)	Develop the block diagram of the PID control scheme in parallel form.	4
	(b)	Justify the following statement: "For a type-0 system, PI-controller can eliminate the steady-state offset for step change in input while P-controller can only reduce it."	4
	(c)	What is *Set Point Kick*? What are the main components responsible for it?	2+2
		Show, with the help of block diagrams, how the PID controller configurations need to be modified to eliminate such phenomena.	8

Q4 (a) Explain, with an example, why in practical applications feed-forward control is generally used in combination with feedback control. 6

(b) What is Ratio Control? 2

With the help of schematic diagrams discuss the different Ratio Control methods. 6

(c) What are *Selectors*? 2

With proper example discuss the operations of *High* and *Median Selectors*. 4

Q5 (a) What is Cascade Control? When does such control scheme become useful? 2+2

(b) Consider the natural draft furnace temperature control problem. Figure Q5(b) shows a cascade control configuration for the furnace, which consists of a primary control loop (utilizing TT and TC) and a secondary control loop that controls the fuel gas pressure via PT and PC.

Develop the block diagram for this cascade control system specifying the variables and controllers associated with the primary and secondary control loops. 10

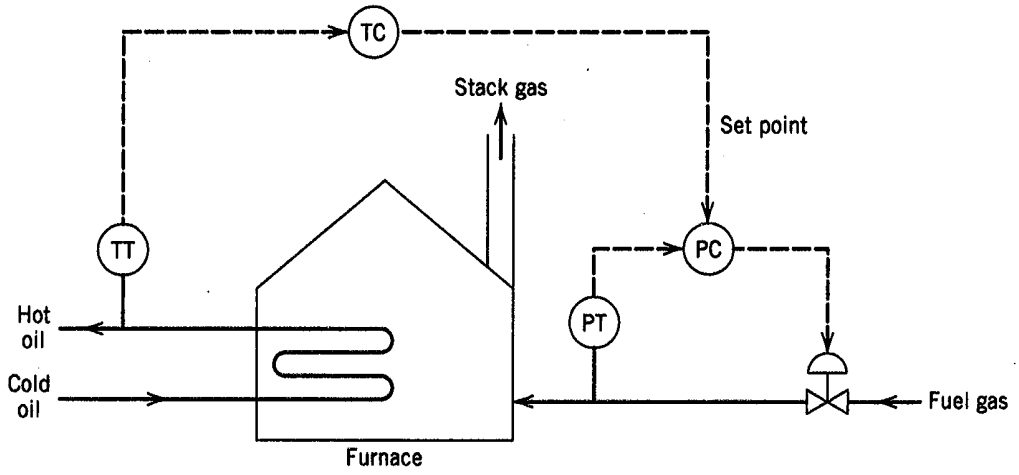

Figure Q5(b)

(c) What is *Inferential Control*? 2

With the help of a block diagram discuss the function of a Soft Sensor in an Inferential Control Scheme. 4