Ref. No.: EX/EE/T/324/2018

B. ELECTRICAL ENGINEERING 3RD YEAR 2ND SEMESTER EXAMINATION, 2018

Subject: PROCESS INSTRUMENTATION & CONTROL **Time: Three Hours** **Full Marks: 100**

Use a separate Answer-script for each Part

Part I (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)	With the help of a schematic diagram define the different process variables and control variables associated with an automatic process control system.	5
	(b)	Describe "Lumped-parameter" and "Distributed Parameter" models with suitable examples.	5
	(c)	For a type-0 system, explain how PI-controller can eliminate the steady-state offset while P-controller can only reduce it.	5
	(d)	With the help of a block diagram discuss the function of a Soft Sensor in an Inferential Control Scheme.	5
Q2	(a)	Describe the methods of determining the parameters of First-Order-Plus-Time-Delay (FOPTD) model from the process reaction curve. Discuss how Integrator-Plus-Time-Delay model can be used to overcome the limitations of FOPTD modeling.	8+4
	(b)	A single-tank process has been operating for a long period of time with the inlet flow rate q_i = 30.4 ft^3/min. After the operator increases the flow rate suddenly at t = 0 by 10%, the liquid level in the tank changes as shown in the Table. Assuming that the process dynamics can be described by a first-order model, calculate the steady-state gain and the time constant.	8

t (min)	0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	3.0	4.0	5.0
h (ft)	5.50	5.75	5.93	6.07	6.18	6.26	6.32	6.37	6.40	6.43	6.45	6.50	6.51	6.52

Q3	(a)	Why PID controller is called a "Gain-Reset-Preact Controller"?	6
	(b)	Describe, stating the assumption, the Ziegler Nichols method of PID controller tuning based on unit step test.	6
	(c)	Consider a control system in which a PID controller is used to control the plant $G(s) = \dfrac{1}{s(s+1)(s+5)}$ Determine the parameters of PID controller by Ziegler-Nichols tuning rule.	8

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Q4 (a) What is feed-forward control? How is it different from feedback control? 2+2

(b) Explain, with an example, why in practical applications feed-forward control is generally used in combination with feedback control. 8

(c) A ratio control scheme is to be used to maintain a stoichiometric ratio of H_2 and N_2 as the feed to an ammonia synthesis reactor. Individual flow controllers will be used for both the H_2 and N_2 streams.

(i) Draw a schematic diagram for the ratio control scheme.

(ii) Specify the appropriate gain for the ratio station, K_R.

Use the following information: 6+2

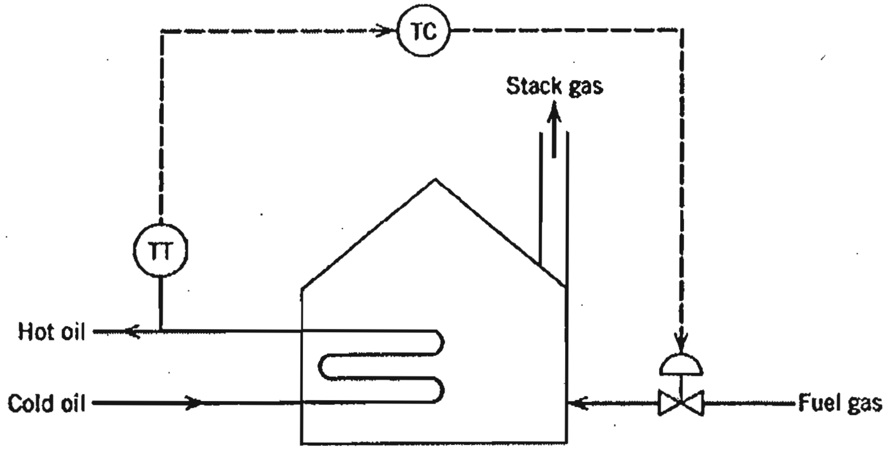
- □ The electronic flow transmitters have built-in square root extractors.
- □ The spans of the flow transmitters are 30 L/min for H_2 and 15 L/min for N_2.
- □ The control valves have pneumatic actuators.
- □ Each required current-to-pressure transducer has a gain of 0.75 psi/rnA.
- □ The ratio station is an electronic instrument with 4-20 rnA input and output signals.

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

(b) Consider the natural draft furnace temperature control problem with conventional feedback control as shown in the Figure.

(i) Assuming that disturbance may occur in fuel gas supply pressure draw the schematic of a Cascade Control scheme.

(ii) Draw the block diagram of the Cascade Control scheme and indicate the process variables. 4+6



(c) The dynamic model between an output variable y and an input variable u is expressed as

$$\frac{d^2y(t)}{dt^2} + 3\frac{dy(t)}{dt} + y(t) = 4\frac{du(t-2)}{dt} - u(t-2)$$ 4+2

(a) Will this system exhibit an oscillatory response after a step change in u?

(b) Find the steady-state gain of the system.

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Full Marks 100
(50 marks for each part)

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No. of Questions	PART II	Marks
	Answer all the questions.	
1.(a)	In a process control application, differentiate between servo problem and regulatory problem. What are the typical parameters by which a process can be characterized?	05
	OR	
	Draw the process instrumentation diagram for boiler drum level control and explain its operation in brief.	05
(b)	A level gauge produces a full scale change in output for a change in level from 0 to 50 cm. What will be the gain of the associated level transmitter? If a 4-20 mA current transmission standard is employed, what will be the current transmitted if the reading of the level gauge is 28 cm?	05
2.	With a neat diagram, explain the operating principle of a pneumatic PI controller. Derive the transfer function of this controller.	10
	OR	
	With a neat diagram, explain the operating principle of a electro-pneumatic actuator. Derive its input-output relation.	10
3.	Write a short note on ***any one*** of the following:	08
(i)	Serial data transmission in presence of noise.	
(ii)	Bias terms and anti-derivative kick features in PID controllers.	
4.	Justify or correct ***<u>any three</u>*** of the following statements with suitable reasons/derivations, in brief.	04×03 =12
(a)	For a first order process with time delay, controlled by a proportional controller, the critical gain increases with increase in time delay.	

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No. of Questions	PART II	Marks
4. (b)	An incremental form of PID controller is employed in process control applications to ensure bumpless transfer between MANual and AUTOmatic modes.	
(c)	The valve sensitivity of an equal-percentage control valve is a constant quantity.	
(d)	A non-interacting analog PID controller can be developed in parallel form using four op-amps.	
5.	An analog PID controller is designed first whose proportional gain is 1.2, integral time constant is 0.84 sec., and derivative time constant is 1.53 sec. This design is then converted to a corresponding digital PID controller using rectangular rule for integration and backward difference algorithm. The sampling time is chosen as 0.1 sec. Determine the values of the coefficients of the digital PID controller designed. Derive all expressions used and draw the realization of the PID controller in block diagram form. How will the design of the digital PID controller change, if (*i*) the integral time constant is increased by 20% from its base value and (ii) the derivative time constant is decreased by 20% from its base value?	10