Ref. No.: EX/EE/T/324/2019

B. ELECTRICAL ENGINEERING 3RD YEAR 2ND SEMESTER EXAMINATION, 2019

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)	Explain with example, "Direct Acting" and "Reverse Acting" mode of process control.	5
	(b)	Discuss the merits and demerits of "Two-Position Control" scheme.	5
	(c)	With the help of a block diagram, briefly describe the principles of Smith Predictor Controller.	5
	(d)	What is Selective Control? Explain the "auctioneering" approach of a Selector.	5
Q2	(a)	With the help of a schematic diagram define the different process and control variables associated with an automatic process control system.	6
	(b)	A perfectly stirred, constant-volume tank has two input streams, both consisting of the same liquid as shown in Figure Q2. The temperature and flow rate of each of the streams can vary with time. Derive a dynamic model that will describe transient operation. Make a degrees of freedom analysis assuming that both Streams 1 and 2 come from upstream units (i.e., their flow rates and temperatures are known functions of time). Here w_i denotes mass flow rate for stream i. Liquid properties are assumed constant (independent of temperature).	8+2
	(c)	What is "Process Time Lag"? What are its principal components?	1+3
Q3	(a)	What is "Set-Point Kick" phenomenon in PID controller? With the help of a block-diagram show how it can be eliminated?	2+4
	(b)	Describe, with necessary assumptions, the Ziegler Nichols methods of PID controller tuning.	8
	(c)	What is Ratio Control? 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. Draw a schematic diagram for the Ratio Control scheme.	2+4

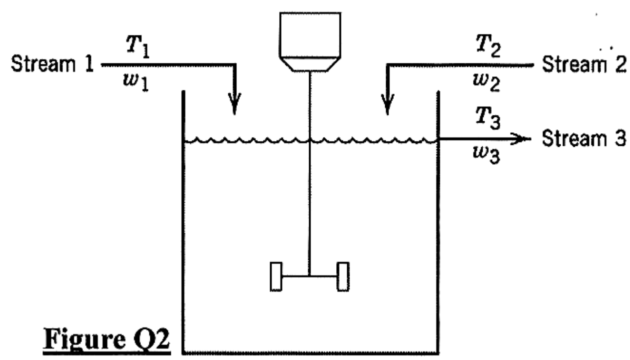

Figure Q2

[Turn over

Q4 (a) What is feed-forward control? With the help of an example, explain why feed-forward control is always used in combination with feedback control? 2+6

(b) Consider the blending system and feed-forward controller shown in Figure Q4. We wish to design a feed-forward control scheme to maintain exit composition x at a constant set point x_{sp} despite disturbances in inlet composition, x_l. Derive the feed-forward control law.
If the measurement of the controlled variable, x, is also available then develop a block diagram to facilitate a feedback-feed-forward control scheme. 6+6

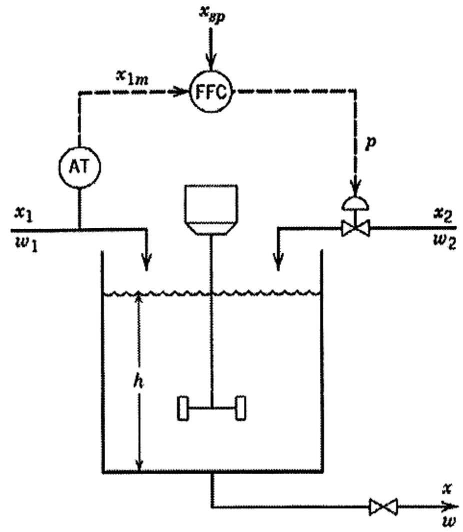

Figure Q4

Q5 (a) What is Cascade Control? Explain, with an example, its benefits over conventional feedback and feed-forward controllers. 2+6

(b) Consider the block diagram of a Cascade Control scheme as shown in Figure Q5 with the following transfer functions: 12

$$G_v(s) = \frac{5}{s+1} \qquad G_{p1}(s) = \frac{4}{(4s+1)(2s+1)} \qquad G_{p2}(s) = 1$$

$$G_{d1}(s) = \frac{1}{3s+1} \qquad G_{d2}(s) = 1 \quad G_{m1}(s) = 0.05 \quad G_{m2}(s) = 0.2$$

Assume both $G_{c1}(s)$ and $G_{c2}(s)$ to be proportional controllers. Show how the Cascade Control scheme would increase the speed of response while reducing the steady-state offset value as compared to conventional Feedback Control for a unit step change in the secondary disturbance variable D_2.

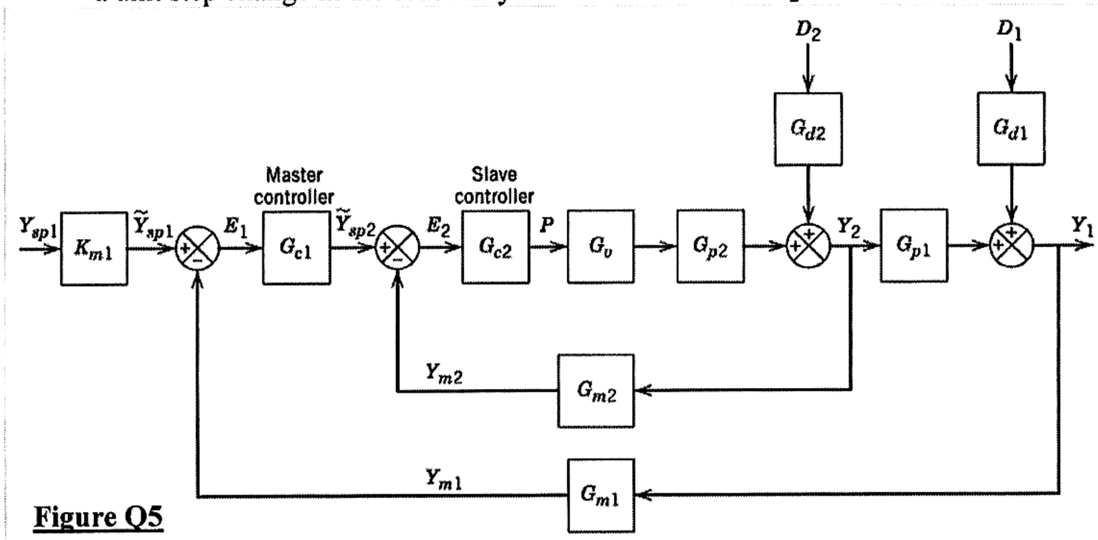

Figure Q5

Ref. No. : Ex/EE/T/324/2019

B. E. ELECTRICAL ENGINEERING 3RD YEAR 2ND SEMESTER EXAMINATION, 2019

SUBJECT: - PROCESS INSTRUMENTATION & CONTROL

Time: Three hours

Full Marks 100
(50 marks for each part)

Use a separate Answer-Script for each part

No. of Questions	PART II	Marks
	Answer all the questions.	
1.(a)	Discuss the importance of a measuring element in a process control loop. What are the popular electrical and pneumatic signal transmission standards employed in process control applications?	05
(b)	Draw the process instrumentation diagram for a liquid level control system with a local pneumatic level controller and explain its operation in brief.	05
	OR	
	Draw the process instrumentation diagram for a flow control system with a differential pressure transmitter and a board mounted electronic flow controller and explain its operation in brief.	05
2.	Why are relay valves employed in process control loops employing pneumatic controllers? With neat diagrams, explain the operating principles of direct-acting bleed type relays, direct-acting non-bleed type relays and reverse-acting relays. How can a direct-acting relay valve be employed in conjunction with a baffle-nozzle amplifier?	10
	OR	
	Derive the input-output relation of a digital PID controller employing trapezoidal rule for integration and backward difference algorithm. How can this controller be modified to incorporate anti-derivative kick feature?	10
3.	Write a short note on ***any one*** of the following:	08
(i)	Smith's method for control of time-delay systems.	
(ii)	Motorized electric actuators and solenoid actuators.	
4.	Justify or correct ***<u>any three</u>*** of the following statements with suitable reasons/derivations, in brief.	04×03 =12
(a)	For both balanced and unbalanced modes of serial data transmission systems, transmitters are provided with hysteresis to reject interference.	

[Turn over

Ref. No. : Ex/EE/T/324/2019

B. E. ELECTRICAL ENGINEERING 3RD YEAR 2ND SEMESTER EXAMINATION, 2019

SUBJECT: - PROCESS INSTRUMENTATION & CONTROL

Full Marks 100

Time: Three hours (50 marks for each part)

Use a separate Answer-Script for each part

No. of Questions	PART II	Marks
4. (b)	In process control applications, a controller must be designed with a limiter at its output.	
(c)	Direct-acting spring-diaphragm type actuators are designed with the spring above the diaphragm and reverse-acting spring-diaphragm type actuators are designed with the spring below the diaphragm.	
(d)	The hard switching option of the anti-integral windup scheme can only be implemented in case of digital PI controllers and not in cases of digital PD or digital PID controllers.	
5.	How does the physical design of the valve plug and valve seat arrangement in a control valve influence the flow-lift characteristics of fast-opening, linear, and equal percentage valves? Prove that the valve sensitivity for a linear control valve is constant and for an equal percentage control valve is proportional to flow rate. Under what circumstances double-seat sliding-stem control valves are implemented in place of conventional single-seat sliding-stem control valves?	10