BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
Second Semester 2021-2022
Comprehensive Exam – Part B (Open book)
Industrial Instrumentation and Control (INSTR F343)

***Time**:120 Minutes* ***Max Marks:** 80* ***Date:**19.05.2022*

***Note**: This question paper has 5 questions. Assume and clearly specify any missing data suitably. Marks are indicated against each question. Unless otherwise specified, assume the final control element and measurement element transfer functions as unity.*

Question 1: Derive the transfer function $G_c(s) = E_0(s)/E_i(s)$ for the analog controller realization as shown in Fig. 1 and express it in the form of $G_c(s) = K_C\left[1 + \frac{1}{T_i s} + T_d s\right]$. Clearly mention the expressions of K_c, T_i and T_d. **[16]**

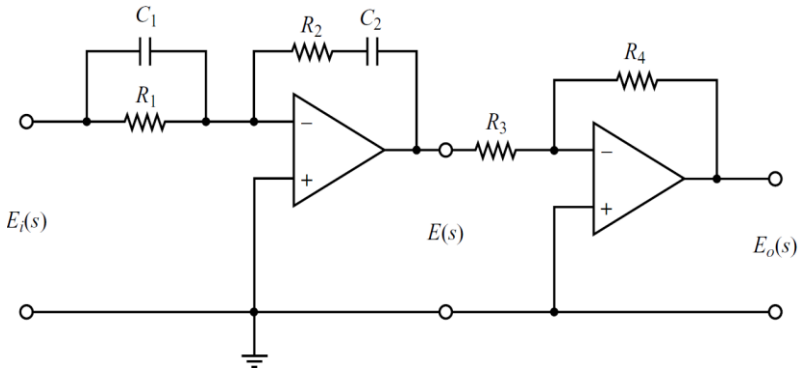

Fig. 1

Question 2: Consider the closed loop control system shown in Fig. 2, where $G(s) = 2/(1 + 10s)$.

(A) Find out the value of proportional gain K_P such that the closed-loop transfer function $G_{CL}(s) = Y(s)/R(s)$, exhibit critically damped response. Given $K_I = 1.8$. **[6]**

(B) Find the transfer function $Y(s)/R(s)$, if a parallel academic PI controller structure is used in place of I-P control strategy. **[4]**

(C) Clearly elaborate the advantage/disadvantage obtained by I-P controller over PI controller by obtaining the time domain expression of $y(t)$ if R(s) is a unit step function. Consider the values of K_P and K_I as obtained in part (A) of this problem. **[8]**

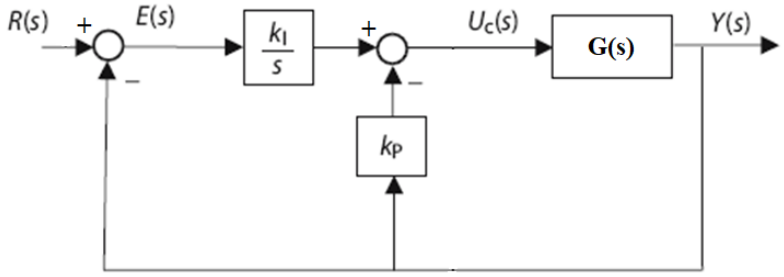

Fig. 2

Question 3: Find the relative gain array (RGA), for the multivariable system, **G**(s), whose transfer function matrix is shown below. **[14]**

$$\begin{bmatrix} Y_1(s) \\ Y_2(s) \end{bmatrix} = \begin{bmatrix} \frac{3}{2s+1} & -\frac{0.5}{(s+1)(s+3)} & \frac{1}{(s^2+3s+2)} \\ -10 & \frac{2}{(s+1)} & \frac{4}{(s+1)(3s+1)} \end{bmatrix} \begin{bmatrix} m_1(s) \\ m_2(s) \\ m_3(s) \end{bmatrix}$$

Question 4: Forced Unit response of two systems [System '1' having a pole at -5 and a zero at -2 and system '2' having a pole at -10 and a zero at -2] is to be trained using ANN. The hidden layer has two neurons, the activation function at the hidden layer is *tanh*, at the output layer is *purelin*.

Show one forward and backward pass for t=1. Weights from input to hidden layers are 0.1, weights from hidden to output layer are 0.2. Bias at hidden and output layer is 0.1. learning rate is 0.5. **[16]**

Question 5: Design a programmed ladder logic diagram having one NO start button (at location I:0/1), which generates a waveform of 1 Hz having a duty cycle of 40% at output O:0/1 for 10 seconds only. You can use only two TON timers (with time base of 0.01 seconds) and an UP counter at location C5:0. Assume the timer addresses are T4:0 and T4:1. **[16]**

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