BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
Second Semester 2022-2023
Comprehensive Exam – Part B (Open book)
Industrial Instrumentation and Control (INSTR F343)

Time:*120 Minutes* ***Max Marks:*** *70* ***Date:***13.05.2023*

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(a): Draw properly labeled waveforms for T1-OFF/DN, T2-OFF/DN & Y for the PLC ladder logic diagram shown in Fig. 1(a).

Question 1(b): For given E0.0, draw properly labeled waveforms for A2.0, A2.1, M0.0 for the ladder diagram shown in Fig. 1(b). What is the purpose of this ladder diagram?

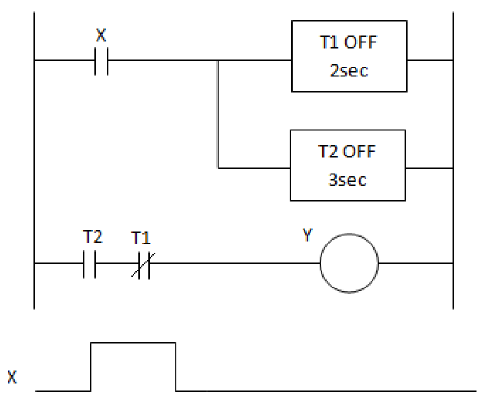

Fig. 1(a)

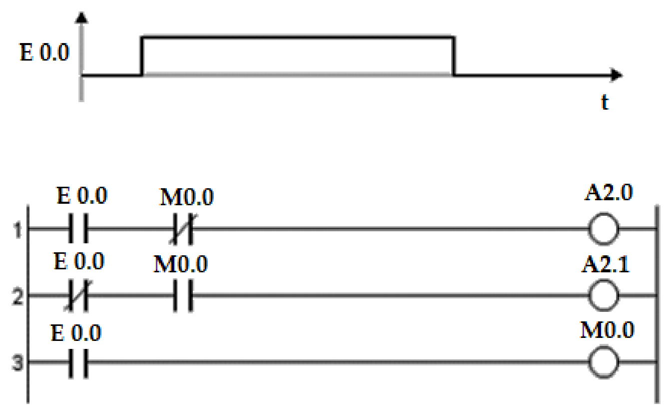

Fig. 1(b)

Question 2: A Fuzzy logic decision system is to be developed for recommending the production of object 'X' depending on the 'demand' and 'stock' of object 'X', all three variables are fuzzified using three membership functions: Low, Medium, High.

The Membership function of 'Low' demand of 'X' has membership degree of 1.0 from units varying between 0-17,200 and is varying from 1.0 to 0.0 linearly from 17,200 to 23,000.

The Membership function of 'Low' stock of 'X' has membership degree of 1.0 for units varying between 0-600 and is decreasing linearly from 1.0 to 0.0 for 600 to 3,500 units. Membership function of 'Medium' stock of 'X' has membership degree of 0.0 for units of 'X' between 0-2,050, and membership degree is increasing linearly from 0 .0 to 1.0 for 2,050 units to 3,500 units, and then membership degree is decreasing linearly from 1.0 to 0.0 for 3,500 units to 4,950 units.

The membership function of 'Low' production of' X' has membership degree of 1.0 for units varying between 0-21,200 and is decreasing linearly from 1.0 to 0.0 for 21,200 units to 27,000 units.

(a) Draw membership functions. Find membership degree of demand & stock to various membership functions given for object 'X" when demand= 18,400, stock = 2,200 [truncated to two decimal places]

(b) Find the crisp output in terms of units to be produced for the cases, **(i)** Mamdani Inference **(ii)** Sugeno using Low as singleton with 23,000 units having membership degree 1.0. Following rules are being fired.

R1: If (DEMAND is L) and (STOCK is L) then (PRODUCTION is L)

R3: If (DEMAND is L) and (STOCK is M) then (PRODUCTION is L)

Question 3: Consider a unity feedback control system that has the open loop transfer function $G_P(s)$. Determine the values of Kc that would keep the closed loop system response stable. Use Pade's first order approximation to approximate dead-time.

$$G_P(s) = \frac{4K_C e^{-2s}}{(s+1)(s+5)}$$

Question 4: Given time constant, train an ANN to find unit step response at t = τ seconds, for,

(i) A first order system with time constant as τ seconds, and **(ii)** second order critically damped system with ($\omega_n = 1/\tau$).

The static sensitivity of both systems is unity.

For ANN, consider, there is one hidden layer with one hidden node, bias (= 0.1) is only at hidden layer, weights from input layer to hidden layer are 0.3, weights from hidden to output layer are 0.5. The activation function at hidden layer is ***ReLu*** and at output layer is ***logsigmoid***, learning rate is 0.1. Truncate values up to four decimals only

a) Draw the architecture of ANN
b) Perform forward pass for τ =1 sec
c) Calculate error vector at hidden and output layer
d) Find change in weight(s) (i) from input layer to hidden layer, (ii) from hidden layer to output layer

Question 5: An innovative way of using a cascade control is to control an unstable system. The inner loop can stabilize the unstable system and the outer loop can be further used for necessary servo and regulatory actions. The block diagram of this use case of cascade control is shown in Fig. 2. Given, $G_P = (s+1)/(s-3)$, which is an unstable system,

(i) Determine the range of K_{c2} value for which the inner loop will remain stable.

(ii) Assume, K_{C2} = 6 and G_{c1} is a PI controller of the form $K_c[1 + {}^{1}/_{\tau_I s}]$, with τ_I = 0.137. Find the value of K_C such that closed loop poles of transfer function relating Y_{SP} to Y are at $s = -0.5 \pm j0.25$.

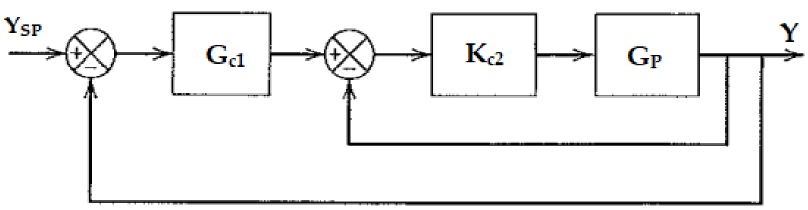

Fig. 2

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