[This question paper contains 8 printed pages.]

3101 *Your Roll No.* .....

MEE **J**

Paper – EE.552

Process Instrumentation and Control

Time : 3 hours *Maximum Marks : 100*

(Write your Roll No. on the top immediately on receipt of this question paper.)

Q. **1** *is compulsory. Answer any* **FOUR** *questions from the remaining.* **All** *questions carry equal marks. Assume suitable missing data, if any.*

1. (a) Write normal operating temperatures for pneumatic system and hydralic system.

(b) Draw a schematic diagram of a pneumatic nozzle flapper amplifier.

(c) Sketch unit step response of the process described by the transfer function.

$$\frac{Y(s)}{X(s)} = \frac{4s+3}{2s+1}$$

(d) What are the two characteristics parameters of a first order process ? How are they determined ?

P.T.O.

(e) Draw a feedforward and feedback control strategy to maintain fluid level in a surge tank.

(f) Write five functions of smart transmitters.

(g) Write name of the materials used to manufacture strain gauge, thermistor, and piezoelectric sensing elements.

(h) Write four features of instrumentation amplifier.

(i) Draw a block diagram of a closed loop differential pressure transmitter operating on the force balance principle.

(j) Write the transfer function of a process having time constant 0.02 sec and steady state gain, 82. (2×10)

2. (a) Draw a block diagram of the pneumatic controller shown in Fig. 1 and derive the transfer function of this controller. Assume that $R_d << R_i$. (10)

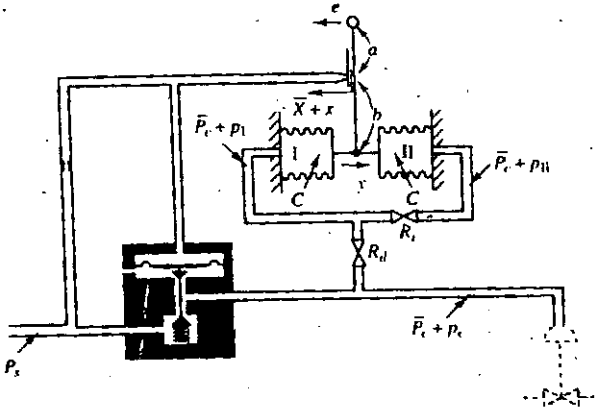

Fig. 1

(b) If a closed loop response is stable with respect to changes in the set point, is it stable to change in the load ? If yes, why ? (10)

3. (a) Discuss the two classes of dynamic performance criteria. Give physical examples and demonstrate how different criteria lead to different controller designs ? (10)

OR

What is the value of the proportional gain K_C for pure dead time system according to the Cohen-Coon settings ? Is it reasonable ? Explain. (10)

(b) Consider a process with the following open loop transfer function

$$g_p(s) = \frac{1}{(s+2)(s-1)}$$

(i) Find the range of K_C for a P controller that will stablize this process.

(ii) It turns out that $K_C = 2$ will yield a stable closed loop for this system. In practice there is a measurement lag in the feedback loop. Assuming a first order lag on the measurement, find the maximum measurement time constant which is allowed before the system (with $K_C = 2$) is destablized. (10)

P.T.O.

4. (a) Derive condition for inverse response characteristic for two composite first order processes. State some practical examples of inverse response system. Discuss the effect of addition of zero on the inverse response of the system. (10)

(b) Consider the following control instrumentation diagram for a heat exchanger shown in Fig. 2.

(i) Construct a control block diagram, labelling all signals and transfer functions include at least one important disturbance input in the block diagram.

(ii) Should the control valve be fail open or fail-closed, why ?

(iii) Based on whether the control valve is fail open or fail closed, is the process gain relating the manipulated valve position (or valve top pressure) to the measured temperature positive or negative ? (10)

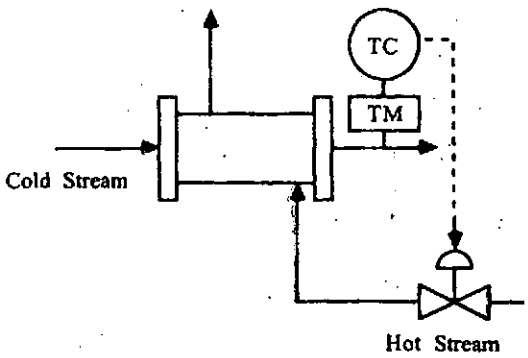

Fig. 2

5. (a) Fig. 3 shows cascade control strategy for a heat exchanger to control the exit temperature of stream 2 at a desired value with a secondary loop to compensate for changes in the flow rate of stream 1. Draw a control block diagram of the scheme and state rules of thumb for cascade control. (10)

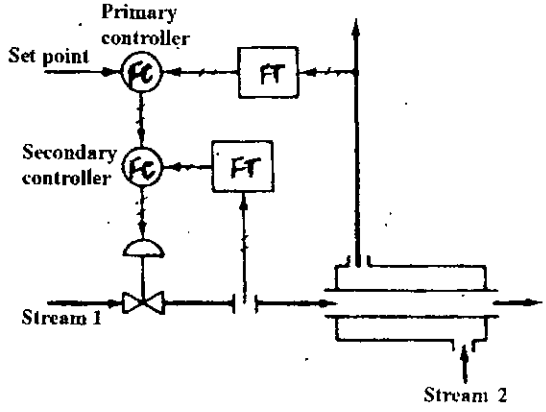

Fig. 3

(b) What is the ratio control and why is it useful in process control ? Give three specific examples. (10)

6. (a) A variable dielectric capacitive displacement sensor consists of two square metal plates, side 5 cm, separated by a gap of 1 mm. A sheet of dielectric material 1 mm thick and the same area as the plates can be slide between them as shown

in Fig. 4. Given that the dielectric constant of air is 1 and that of the dielectric material 4, calculate the capacitance of the sensor when the input displacement is 5 cm. (10)

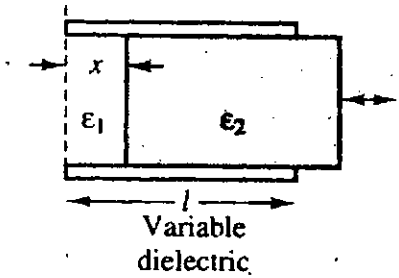

Fig. 4

(b) Derive output voltage expression for reactive deflection bridge used with capacitance level transducer shown in Fig. 5. The capacitance of level transducer is

$$C_h = \frac{2\pi \epsilon_0}{\log_x b/a} [\ell + (\epsilon - 1)h]. \quad (10)$$

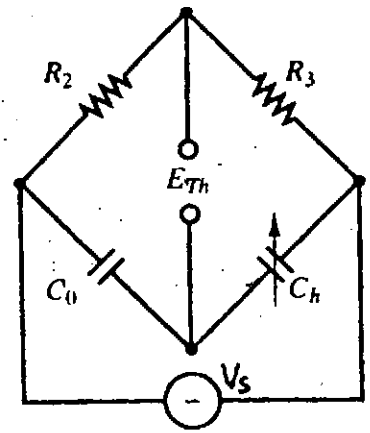

Fig. 5

OR

(b) Explain principle of operation of a piezoelectric sensors. Why secondary displacement sensor is not required for piezoelectric sensor ? Explain with help suitable equations, that piezoelectric effect is reversible. (10)

7. (a) Describe with help of neat sketches and performance equations different types of pressure sensing elements. (10)

(b) Four strain gauges with specifications given below, are available to measure the torque on a cylindrical shaft 4 cm in diameter connecting a motor and load.

Strain gauge data : resistance = 120 Ω
gauge factor = 2.1
maximum current = 50 mA

(i) Draw labelled diagrams showing :

the arrangement of the gauges on the shaft and also arrangement of the gauges in the bridge circuit for optimum accuracy and sensitivity. Calculate the maximum achievable bridge out of balance voltage for an applied torque of 10^3 N-m given the following :

Tensile and compressive strains = $\pm \frac{T}{\pi S a^3}$

where $S = 1.1 \times 10^{11}$ N-m^{-2} is the shear modulus of the shaft material and a is the radius of the shaft in meters. (10)

8. Write short notes on any **four** of the following :

(i) Feedforward control

(ii) Current transmitters

(iii) Thermistor

(iv) Linear Variable Differential Transformer (LVDT)

(v) Inductive displacement sensors (4×5)