Agricultural and Food Engineering Department

Date_23.04.12 (AN) **Time:** 3 Hrs. **Full Marks:** 50 **No. of Students:**26

Spring Semester 2011-12 **Subject No.:** AG60148 **Subject Name:** Instrumentation and Control in Food Industry for IVth year B. Tech. (H), DD (FPE), Ist year M. Tech. (FPE) and R/S in Agricultural and Food Engineering

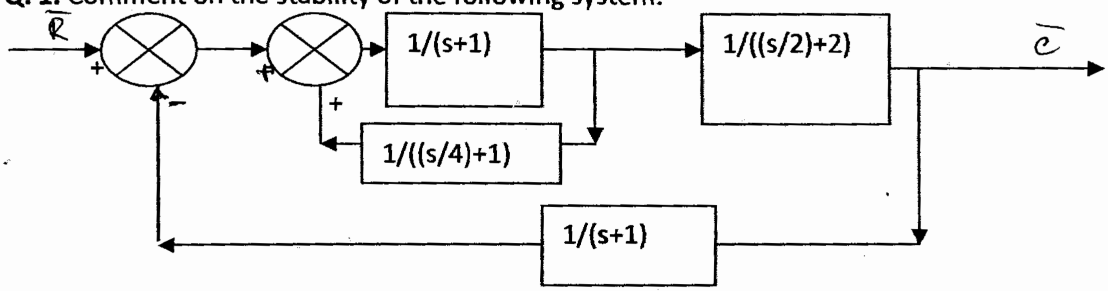
Instructions: Part A is compulsory. Answer any four questions from **Part B.**

Part A (Compulsory)

1. A platinum-platinum/Rhodium thermocouple was found to have linear calibration between 0 and 1400 ºC with full range value of 16.8 mV while the reference junction temperature was 0ºC. This thermocouple was used to measure the temperature of a baking oven while by mistake the cold junction was made with a salt-contaminated ice-water whose freezing point was -5ºC. The temperature of the oven needs to be maintained at 250ºC. If the thermocouple showed an emf equal to 3 mV, what was the actual temperature of the oven? **[10]**

Part B (Answer any four questions)

Q. 1. Comment on the stability of the following system: **[10]**



Q. 2. A negative feedback control loop with PI controller of Kc and τ_I =0.5 s is connected through a second order process having τ_1 = 1 s and τ_2 = 0.5 s along with an instrument having measurement time constant of τ_3 = 0.333 s. Obtain the value of K_c for which the system is on the threshold of instability and corresponding locations of the roots on the imaginary axes. If the K_c value is increased to 5 along with insertion of a derivative component having τ_D as derivative time constant, then obtain the minimum value (up to one decimal place) of τ_D for which the new system is unconditionally stable. **[4+2+4]**

Q. 3. The response of a first order process with time constant of 3 s is being measured with a second order instrument having time constants of 5 s and 4 s. The system is negatively feedback to a controller having proportional gain of K_c and an integral time constant of 2 s. Calculate:

(a) the OLTF of the system; (b) the pole(s) and zero(s) of the system; (c) the number of asymptotes; (d) the centre of gravity and the angles of emergence; (e) the value of K_c for which the system is on the verge of instability and (f) the position of all four roots at the threshold of instability. **[2+1+1+2+2+2]**

Q. 4. A mercury thermometer having a time constant of 15 s is placed in a temperature bath at 50 °C and is allowed to come to equilibrium with the bath. At time t = 0 the temperature of the bath begins to oscillate with an amplitude of 2 °C. If the frequency of oscillation is (15/π) cycles min $^{-1}$ what is the temperature shown by the thermometer after 15, 30 and 45 s? **[10]**

Q. 5. A PI controller with τ_I =10 s is used to control the steam supply to the heater in a tank being fed 1 L s $^{-1}$ water at a fixed temperature. If this temperature is suddenly raised by 5 °C then obtain the tqank temperature after 50 and 100 and 200 s. $K_c = 10^3$, $\rho = 10^3$ kg m $^{-3}$, C_p = 4.2 kJ kg $^{-1}$ K $^{-1}$, tank volume = 20 L. **[10]**