Birla Institute of Technology and Science, Pilani

First Semester 2008-2009

AAOC C321: Control Systems
Comprehensive Examination

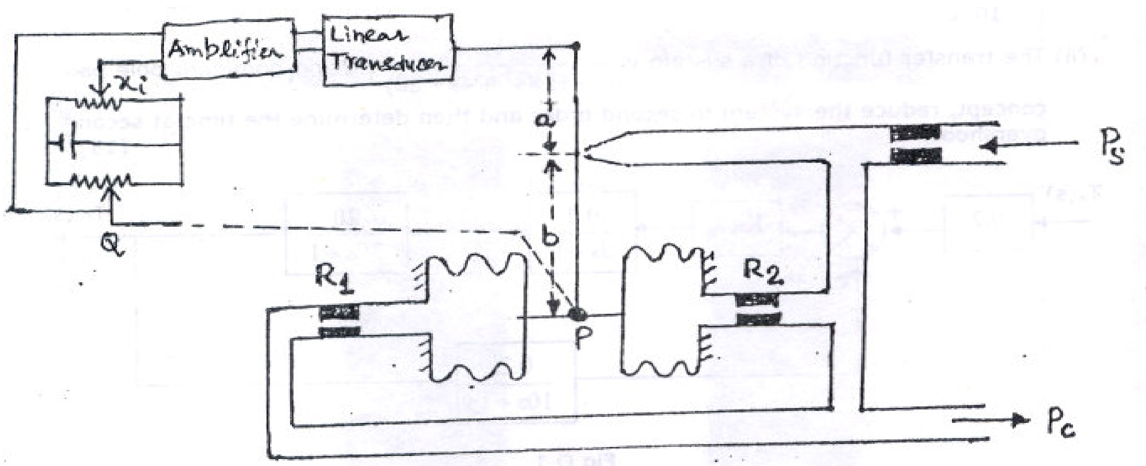
Date: 08.11.2008 **Time: 3 Hrs** **MM: 120**

Q1. An electro pneumatic control system is shown in figure below. Capacities of bellows are C_1 and C_2 respectively and pressure P_C is related to flapper displacement by a constant K_f. Area and stiffness coefficient of each bellow is A_b and K_b respectively. The sensitivity of potentiometer pair is K_1V/m, amplifier gain is K_2 V/V and linear transducer gain is K_3 m/V. The points P and Q are connected (i.e. Points P and Q have same displacement). For this system

(a) Draw the block diagram

(b) Determine the transfer function $\dfrac{P_c(s)}{X_i(s)}$ and

(c) Determine the steady state value of output for 3 units of sudden input. [10+6+4]



Q2. The block diagram of a control system is shown in Fig. Q.2. For this system:

(i) Clearly show the region in K-α Plane that can be used without instability arising.

(ii) Determine the values of K and α so that the system has damping ratio of 0.707 and settling time of 2 sec for 2% tolerance band. Also sketch the real axis locus of the roots.

(iii) Draw the neat sketches of root contours for K=11.25 and 18.25.clearly show the steps involved. [7+12+6]

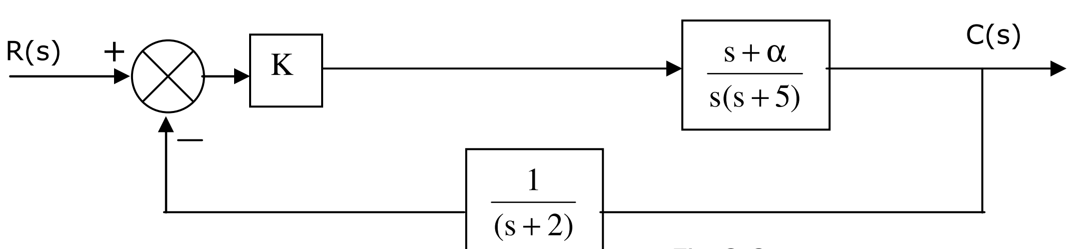


Fig Q.2

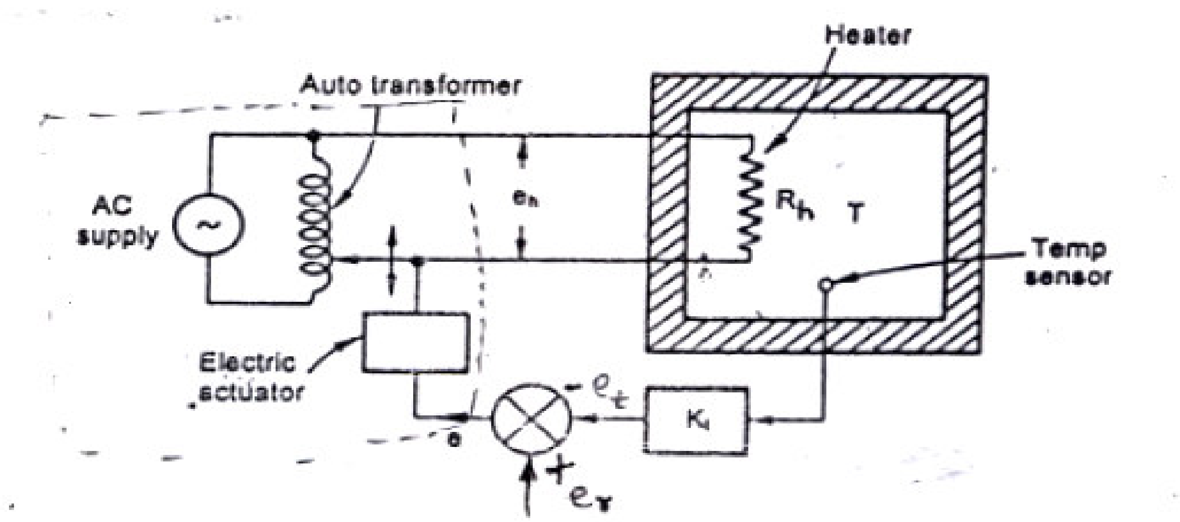
PTO

Q.3 Sketch the Nyquist plot for a system whose open loop transfer function is $\frac{K(s-3)}{s(s+2)(s+5)}$, choosing the appropriate Nyquist contour. Determine the range of K for which the closed loop system is stable. [25]

Q.4 A temperature control system is shown in Fig Q.4.The various parameters of this system are as follows:

Autotransformer setting is set by an electric actuator, gain of this complete assembly is K_a V/V; Thermal resistance of tank is R °C/W; Thermal capacitance of the mass in tank is C J/°C; Temperature sensor constant is K_t V/ °C. J is Joule's coefficient. For this system

i. Draw the labeled signal flow graph
ii. Obtain the incremental transfer function, $\Delta T(s)/ \Delta e_r(s)$
iii. Derive the expression for sensitivity of the system for changes in K_a in open loop & closed loop mode and reduce this for DC conditions.
iv. If the inlet temperature is also varied, draw the modified signal flow graph and determine the the incremental transfer function, $\Delta T(s)/ \Delta T_i(s)$. [6+3+6+5]



Q.5 The open loop transfer function of a unity negative feedback systems is given by $\frac{K}{s(1+2s)(0.1s+1)}$.

Design the Phase lead compensator using Bode's magnitude (asymptotic) and phase plots to meet the following specifications:

(a) Steady state error for unit ramp input ≤ 20%
(b) Phase margin is 40°, take factor of margin as 10°.

Also draw the Bode plots for overall system including compensator.
(Semi-log graph sheet is provided for the same). [30]