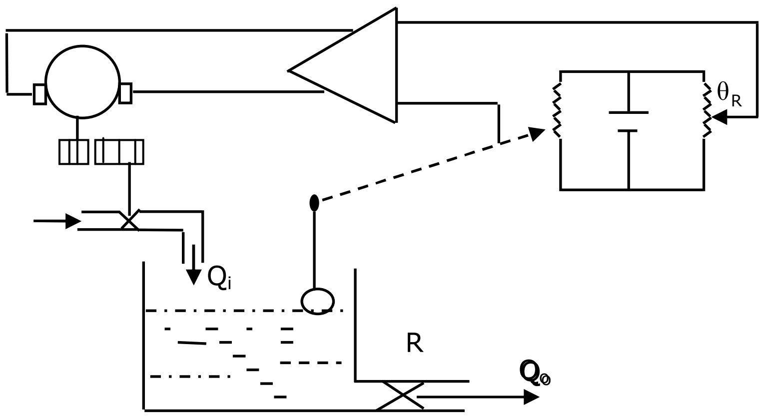
Birla Institute of Technology and Science, Pilani

Second Semester 2009-2010

AAOC C321: Control Systems
Comprehensive Examination (Closed Book)

Date: May 7th, 2010(FN) **Time: 3 Hrs** **MM: 120**

Q1. An armature controlled DC servo motor is used to control the liquid level (H) in a tank as shown below. Motor is driving the valve through a gear train of reduction ratio 1: 5.The various parameters of this system are as follows:



Amplifier gain (K_A) = 10 V/V;
POT sensitivity (K_P) = 5 V/rad
Torque constant (K_T) =1 Nm/A;
Back e.m.f. constant (K_b) = 1 V/rad/s
Armature Resistance (R_a) = 1 Ω
Moment of Inertia of valve (J_v) = 12.5 kg.m^2
Friction Coeff. Of Load (B_v) = 6.25 Nm/rad/s
Moment of Inertia of motor (J_m) = 0.5 kg.m^2
Friction Coefficient of motor is negligible
Tank capacity (C) = 1 Unit
Outflow resistance (R) =2 units
Valve orifice coefficient (K_V) = 0.5
Float linkage coefficient (K_f) =1 rad/m

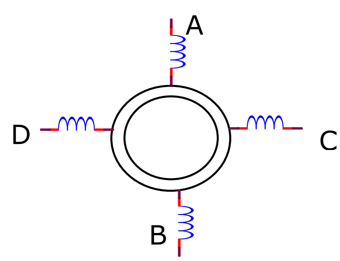
For this system:

(a) Draw the block diagram

(b) Determine the transfer function $\frac{\Delta H(s)}{\Delta\theta_R(s)}$

(c) Determine whether the –ve real part of the closed loop poles are more negative than -1

(d) Tabulate the sequence of signals to rotate a permanent magnet stepper motor shown below, in both directions by 90°in each step. The starting position of magnetization is A & D ON and B & C OFF. [10+4+6+10]



Q2.(a) Sketch the Nyquist plot for a system whose open loop transfer function is $\frac{K(s+3)(s+4)}{s(s\quad 4)(s+5)}$, choosing the appropriate Nyquist contour and therefrom determine the range of K (K>0) for which the closed loop system is stable. Also determine the Gain Margin for K=1.

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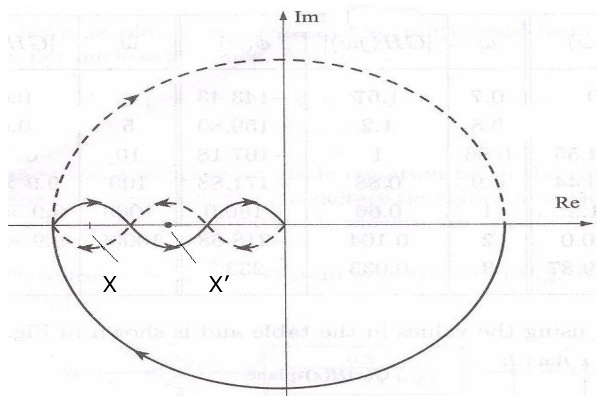
(b) The Nyquist plot for a system is shown below. The system has no open loop pole in RHP. Comment on the closed loop system stability using Nyquist stability criterion when (i) the point x is -1+j0 and (ii) the point x′ is -1+j0 . [25+5]



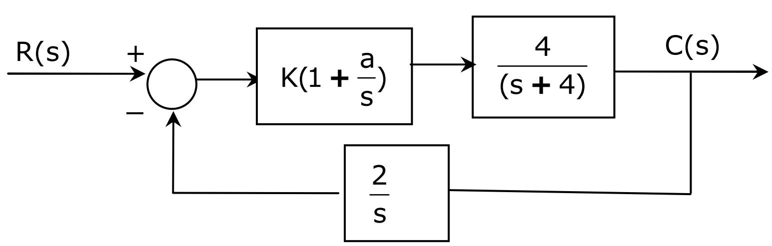
Q3.The block diagram of a control system is shown below. For this system

(a) Draw the neat sketches of root contours for a= 3 and a=5, clearly showing all the steps involved ($0<K<\infty$)

(b) Determine the range of ‘a’ for which system is stable ($0<K<\infty$)

(c) Determine the steady state error for an input of $(t^2/2)\,u(t)$

(d) It is observed that for a certain value of K, the settling time (2% tolerance Band) of the system is 10 s and peak overshoot is 43% (corresponding to the dominant pole pair). Determine the value of this K and corresponding location of the third closed loop pole? Take ‘a’=1.5. [12+5+5+8]



Q4. (i) The open loop transfer function of a system is $\dfrac{K(s+5)}{s^2(s+50)}$.

(a) Draw the Bode’s magnitude (asymptotic) and phase plots (for K=80) and therefrom determine the value of gain & phase cross over frequency and Gain & Phase Margin.

(b) Determine the value of K for the system to have phase margin of 45°.
(Use Semi-log graph sheet, provided for the same)

(ii) The Bode’s magnitude (asymptotic) is shown in figure below; determine the transfer function for which this is drawn. [25+5]