Birla Institute of Technology and Science, Pilani

First Semester 2009-2010

AAOC C321: Control Systems
Comprehensive Examination (Closed Book)

Date: December 8th, 2009(FN) **Time: 3 Hrs** **MM: 120**

Q1. An ac-dc servo system is shown in figure below. The various parameters of this system are as follows:

Amplifier gain (K_A) = 5 V_{dc}/V_{dc} ; Synchro pair sensitivity (K_s) = 7 V_{rms}/rad
Demodulator gain (K_d) =3 V_{dc}/V_{rms} ; Torque constant (K_T) =1 Nm/A
Back e.m.f. constant (K_b) = 1 V/rad/s; Motor Armature Resistance (R_a) =1Ω
Moment of Inertia of load (J_L) = 5 kg.m^2
Friction Coefficient of load (B_L) = 2.5 Nm/rad/s
Moment of inertia of motor (J_m) is 1 Kg. m^2 ;
Friction Coefficient of the motor (B_m) is 0.55 Nm/rad/s.

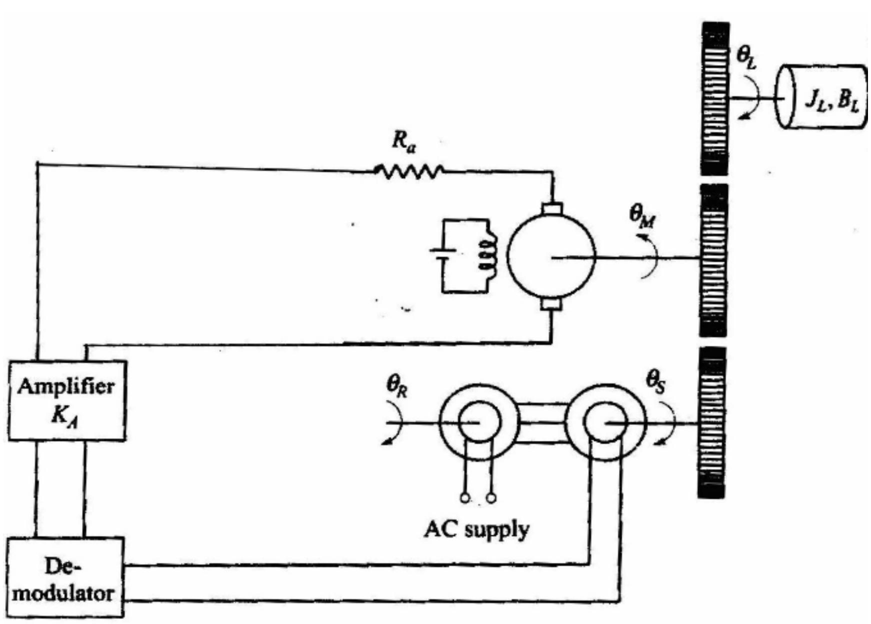
Gear ratios: $\frac{\dot{\theta}_M}{\dot{\theta}_L} = \frac{10}{1}$ and $\frac{\dot{\theta}_M}{\dot{\theta}_s} = \frac{1}{5}$

For this system,

(a) Draw the block diagram

(b) Determine the transfer function $\frac{\theta_L(s)}{\theta_R(s)}$ and

(c) Determine the rise time. [10+6+4]



Q2. Sketch the Nyquist plot for a system whose open loop transfer function is $\frac{K(s+1)}{s^2(s \quad 2)}$, choosing the appropriate Nyquist contour and therefrom determine the range of K (K>0) for which the closed loop system is stable. Verify your answer using Routh stability criterion. [20+5]

PTO

Q3. Consider the system given in Fig Q3. When the system is subjected to a unit step input the output has peak overshoot of 16.3% but ultimately attains the final value of 1 unit. The response to a ramp input has a steady state error of 0.0625 unit.

(a) Find the values of K, a & b (all three are ≥ 0),

(b) For the system with above calculated values, add a suitable error controller (Gain K_1) to get steady state error as zero and determine the range of K_1 for system to be stable,

(c) Draw the root contours of the system for two values of K (8 & 13) and $0 < K_1 < \infty$. Keeping the values of a and b as calculated above. [7+ 6+12]

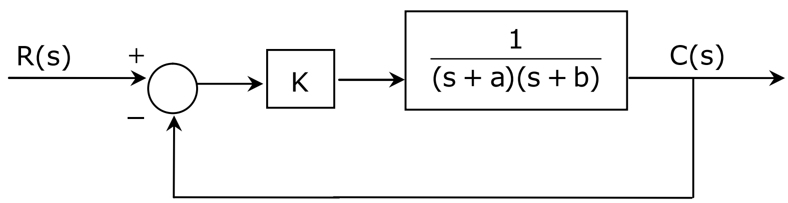


Fig Q3.

Q4. A control system is represented by the following equations:

$y = 2x - 4z - 5u$; $z = 3y - 3w + \dot{z}$; $w = 2z$; $u = w + 2\dot{z}$

For this system

(a) draw the signal flow graph (without solving the equations) and determine the transfer function $\frac{U(s)}{X(s)}$ using Mason's Gain Formula.

(b) Suppose the above calculated transfer function is an open loop transfer function for a unity negative feedback system, draw the polar plot of the system and calculate the Gain Margin & Phase Margin of this system.

[15+5]

Q5. The open loop transfer function of a unity negative feedback system is given by:

$$\frac{K}{s^2(0.4s+2)}$$

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

- Acceleration error constant (K_a) = 5 and
- Phase margin is 10°, take factor of margin as 10°.

Also draw the Bode plots for the compensated system.

(Semi-log graph sheet is provided for the same). [30]

******* ALL THE BEST *******