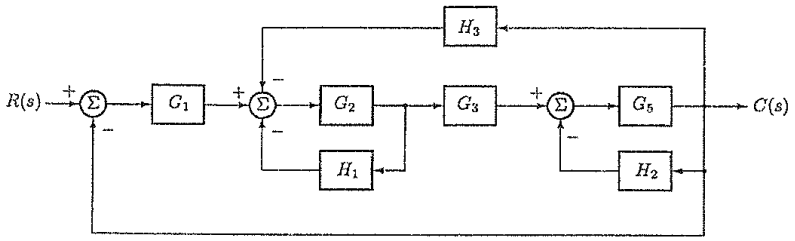
Kafrelsheikh University
Faculty of Engineering
Electrical Engineering Department
Final Exam, 2016 -2017

3rd Year (Electrical Engineering)
Automatic Control (2)
Time: 180 minutes
Mark: 90
Dr. Abdel-Fattah Heliel

Answer all the following questions:

Problem 1: (20 points)

a) For the control system shown below:
   i. Draw the corresponding Signal Flow Graph. . **(4 points)**
   ii. Determine the transfer function C(s)/R(s) using Signal Flow Graph. **(6 points)**



b) For the control system $G_f(s)=\dfrac{K}{s(s+1)(s+4)}$. design a phase lead compensator to meet the following time-domain specifications: Dominant poles damping ratio ζ= 0.5 , and natural frequency $\omega_n=2$. **(10 points)**

Problem 2: (20 points)

a) Define gain margin and phase margin and explain graphically. What do the gain margin and the phase margin indicate? **(8 points)**

b) Draw the bode diagram of the following transfer function:

$$G(j\omega)=\frac{5(1+j0.1\omega)}{j\omega(1+j0.5\omega)(1+j0.6\frac{\omega}{50}+\left(\frac{j\omega}{50}\right)^2)}$$

After plotting Bode diagram evaluate the gain margin and the phase margin of the system and Comment on the stability of the system whose Bode diagram. **(12 points)**

Problem 3: (20 points)

a) Derive the relationship between state space representation and transfer function? and draw the block diagram of state space representation?**(10 points)**

b) A useful component in many real control systems is a permanent magnet DC servo motor. The input signal to the motor is the armature voltage V_a (t), and the output signal is the angular position θ(t). A schematic diagram for the motor is shown in Figure 2. The terms R_a and L_a are the resistance and inductance of the armature winding in the motor, respectively. The voltage V_b is the back EMF generated internally in the motor by the angular rotation. J is the inertia of the motor and load (assumed lumped together), and B is the damping in the motor and load relative to the fixed chassis. Determine the State Space Equations and Simulation diagram for the DC servo motor. **(10 points)**

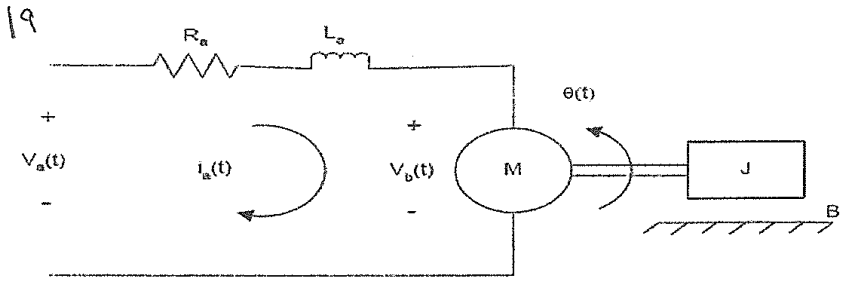


Figure 2: Schematic diagram of a DC servo motor.

Problem 4: (20 points)

a) What do you mean by compensation. Describe the three types of compensation? **(9 points)**

b) Consider a unity feedback system having an open-loop transfer function,

$$G(j\omega) = \frac{K}{j\omega(1+j0.2\omega)(1+j0.05\omega)}.$$

Draw the polar plot of the system and Comment on the stability of the system. **(11 points)**

Problem 5: (15 points)

a) What is controllability and observability of control systems? **(5 points)**

b) Consider the type 1 servo system shown in Figure 3. Matrices A, B, and C in Figure 3 are given by: **(10 points)**

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -5 & -6 \end{bmatrix}, \quad B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \quad \text{and} \quad C = [1 \quad 0 \quad 0]$$

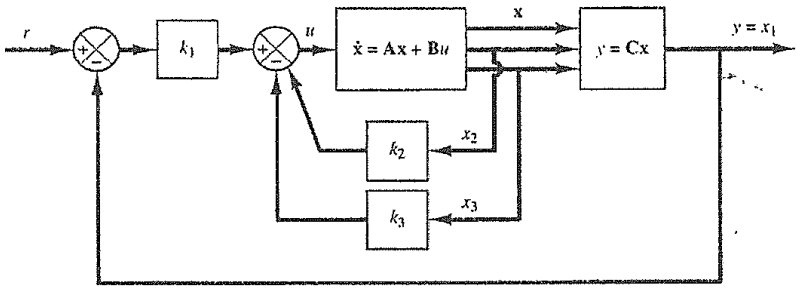


Figure 3

Determine the feedback gain constants k_1, k_2, and k_3, such that the closed-loop poles are located at $s_1 = -2 + j4$, $s_2 = -2 - j4$, $s_3 = -10$.

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