Assignment 5

The plant to be controlled is described by the transfer function

$$G_p(s) = \frac{280\,(s+0.5)}{s\,(s+0.2)\,(s+5)\,(s+70)} = \frac{2\,(s/0.5+1)}{s\,(s/0.2+1)\,(s/5+1)\,(s/70+1)}$$

The specifications that must be satisfied by the closed-loop system are:

- steady-state error for a ramp input $e_{ss\_specified} \leq 0.02$;
- phase margin $PM_{specified} \geq 55°$;
- gain crossover frequency $\omega_{x\ specified} = 5$ r/s.

Consider the uncompensated system

$$G(s) = \frac{20K}{s(s+2)(s+10)}$$

Use the Nyquist plot to design a phase lead compensator and a gain K that will achieve a phase margin in the range of 30° to 40° and a gain margin in the range of 8dB to 12 dB.

A unity feedback system has an open-loop transfer function

$$G(s) = \frac{200K}{s(s+2)(s+5)}$$

Obtain a Bode plot for this system when $K = 1$ and find the phase and the gain margins. Design a lag compensator in order to achieve a phase margin of approximately 45° and a minimum gain crossover frequency of $\omega = 1$ rad/sec.

A unity feedback system has an open-loop transfer function

$$G(s) = \frac{2K}{(s+2)(s+0.4)(s+0.2)}$$

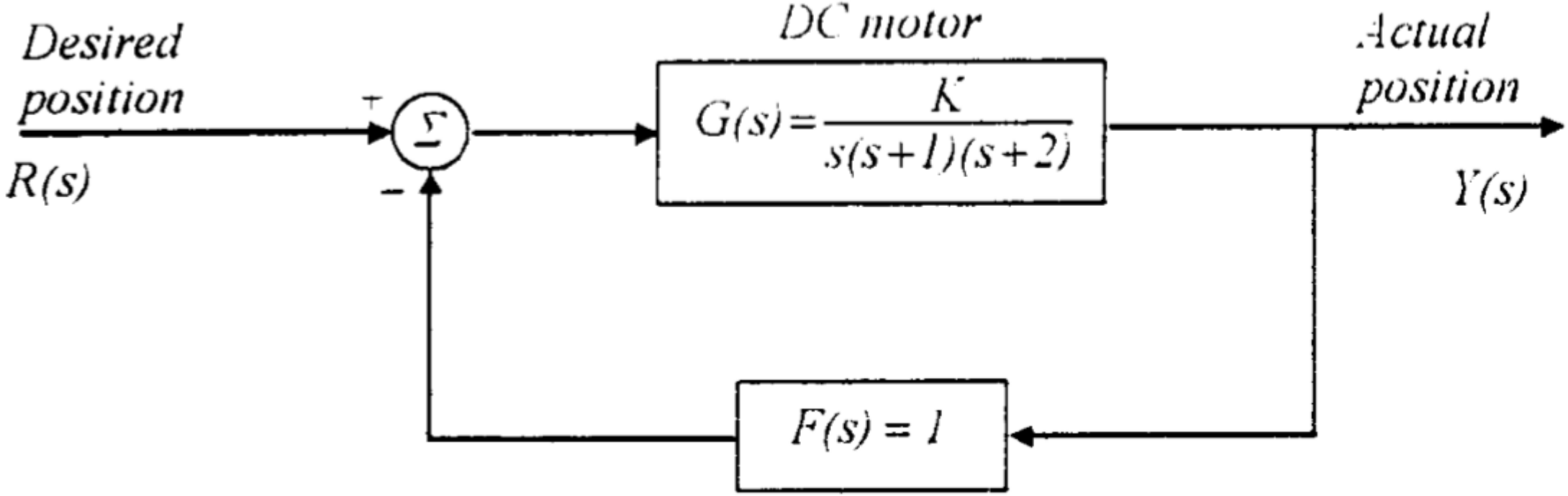
By means of a Bode plot, when $K = 1$, find the phase and the gain margins, and the bandwidth. Also, find the range of values for K, over which the closed loop system will be unstable.

When a step input of magnitude 0.04 units is applies to a certain open-loop system, the output response in equal to [6-6exp(-t)] units. Obtain the Bode-plot for this system and find the phase and gain margins.

A phase lead compensator of the form

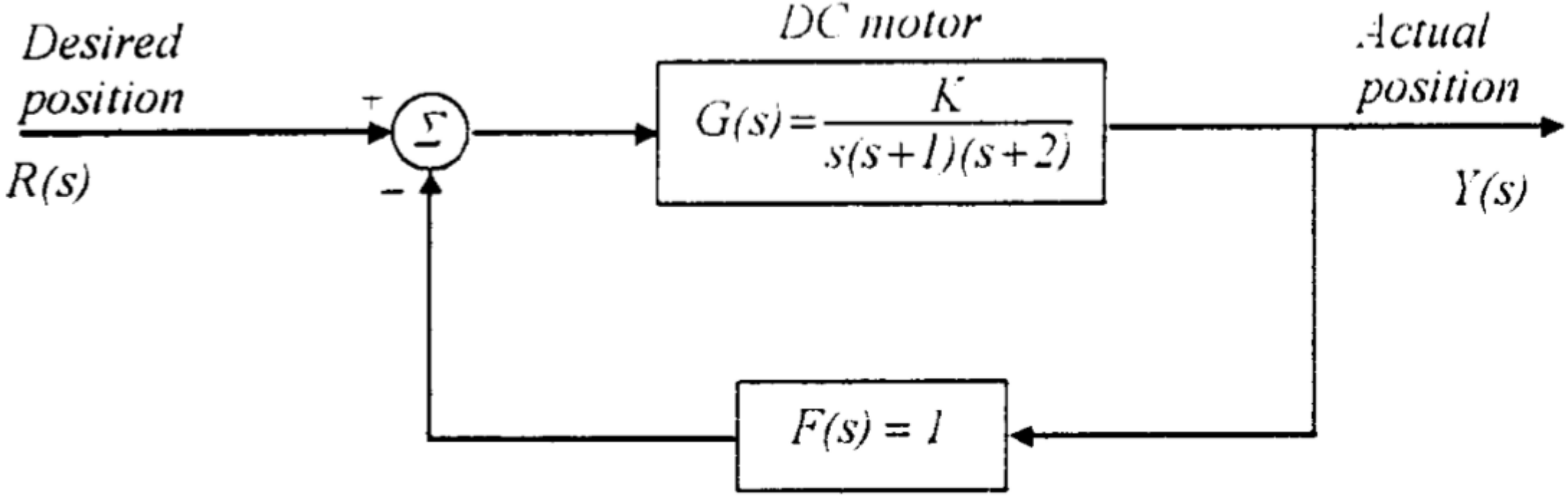
$$D(s) = \frac{5(s+\beta)}{(s+5\beta)}$$

is employed for this system such that the phase margin is approximately 45°. What value of β is required for such a design?



Consider a field-controlled DC motor represented by the block diagram in Figure . Draw the Nyquist diagram. Furthermore:

(a) Determine the gain K so that the gain margin is 20 dB
(b) Determine the value of K so that the phase margin is 60°.



Consider the field-controlled DC motor system

(a) For $K = 4$, plot the Bode diagram of the system, find the phase-crossover and gain-crossover frequencies and determine the gain margin and the phase margin. Is the system stable?

(b) Determine the value of K for which the phase margin is 50°.

(c) Find the value of K so that the gain margin is 16 dB.

The Block diagram of a chemical process whose production rate is a function of catalytic agent is shown in Fig. P8.8. The transfer function $G_p(s)$ of the reactor is given below where the time delay is 40 sec. Design a compensator by frequency-domain method which will ensure a phase margin $\geq 35°$ and steady state error to a step input less than 0.1. Also find the settling time of the closed loop system.

$$G_p(s) = \frac{e^{-sT}}{(25s+1)^2}$$