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Indian Institute of Technology Hyderabad

Indian Institute of Technology Hyderabad

Department of Electrical Engineering

EE2220 – Control Systems

Assignment 03 – (Design in Frequency Domain)

Submission Deadline: None

Key Learning from the Assignment:

- Designing Lead, Lag and Lead-Lag compensators

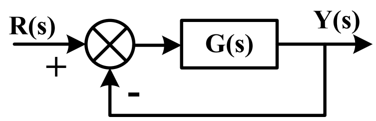

Figure 1

__Instructions:__ RN = last two digits of your roll number.
Use Graph paper for all plots/ sketches.

1. For a unity feedback system shown in Fig. 1, having transfer functions given below, (i) Design the value of gain (K) for a gain margin of RN dB. (ii) Design the value gain (K) for a phase margin of 40°. (iii) Design the value of gain (K) to yield maximum peak overshoot of 20% for a step input.

   a. $G(s)=\dfrac{K}{(s+3)(s+9)(s+15)}$

   b. $G(s)=\dfrac{K(s+2)}{s(s+4)(s+3)(s+5)}$

2. For a unity feedback system shown in Fig. 1, $G(s)=\dfrac{K}{s(s+1)}$. Design a lead compensator such that the phase margin of the system is 45° and appropriate steady state error is less than or equal to 1/15 units of the final output value. Further the gain crossover frequency of the system must be less than 7.5 rad/sec.

3. Given the unity feedback system of Fig. 1, with $G(s)=\dfrac{K(s+10)(s+11)}{s(s+3)(s+6)(s+9)}$. Use frequency response method to design a lag compensator to yield K_v = 1000 and peak overshoot of 15%. Design a passive network to implement the compensator.

4. For a unity feedback system shown in Fig. 1, $G(s)=\dfrac{K}{s(s+2)(s+4)(s+6)}$.

   a. Design a lead compensator to yield a $K_v = 2$ and a phase margin of 30°.
   b. Design a lag compensator to yield a $K_v = 2$ and a phase margin of 30°.
   c. Design a lag-lead compensator to yield a $K_v = 2$ and a phase margin of 30°.
   d. Use MATLAB/SCILAB to validate if your design in (a), (b) and (c) yields required phase margin or not. If your design is not satisfactory, redo the design using software of your choice.
   e. Compare performance of compensators designed in (a), (b) and (c) in terms of the following: bandwidth, peak time, maximum peak-overshoot, settling time. Use software of your choice.

5. Given the unity feedback system of Fig. 1, with $G(s)=\dfrac{K}{s(s+5)(s+20)}$. The uncompensated system has about 55% peak overshoot and a peak time of 0.5 second when K_v = 10. Use frequency response technique to design a lead compensator to reduce the percentage overshoot to 10%, while keeping the peak time and steady state error about the same or less.
6. For a unity feedback system shown in Fig. 1, $G(s)=\dfrac{10e^{-0.02s}}{(0.5s+1)(0.1s+1)(0.05s+1)}$. Design a suitable compensator so that the system acquires a damping factor of 0.4 without loss of steady state accuracy. Estimate bandwidth and settling time of the compensated system.
7. An aircraft roll control system can be represented by a block diagram shown in Fig. 1, with $G(s)=\dfrac{10K}{s(s+1)(s+5)}$.
   a. Design a lead compensator for a 60° phase margin and an appropriate error constant of 5.
   b. Design a lag compensator for a 60° phase margin and an appropriate error constant of 5.
   c. Design a lag-lead compensator for a 60° phase margin and an appropriate error constant of 5.
   d. Evaluate performance of the compensated system in terms of peak overshoot, peak time, settling time and steady state error for appropriate input.
8. Using frequency response method, design a lag-lead compensator for the unity feedback system shown in Fig. 1; consider $G(s)=\dfrac{K(s+7)}{s(s+5)(s+15)}$. The following specifications must be met: Peak overshoot = 15%, settling time = 0.1 second and velocity error constant = 1000.
9. For the unity feedback system shown in Fig. 1, with $G(s)=\dfrac{K}{s(s+1)(s+4)}$. Design a lag-lead compensator to yield 5 fold improvement in steady state performance as well as peak overshoot of 12% and peak time of less than or equal to 2 seconds.
10. For the unity feedback system shown in Fig. 1, with $G(s)=\dfrac{K}{(s+3)(s+9)(s+15)}$. Design a lag-lead compensator to yield appropriate error constant = 5, phase margin = 45° and bandwidth = 15 rad/s.