EE324, Control Systems Lab, Problem sheet 9
(Report submission date: 4th April 2021)

Q1) Compare Nyquist plots of a transfer function G(s) = $\dfrac{10}{s\,(\frac{s}{5}+1)\,(\frac{s}{20}+1)}$ and C(s)G(s), where C(s) is:

i) A lag compensator with transfer function $\dfrac{s+3}{s+1}$

ii) A lead compensator with transfer function $\dfrac{s+1}{s+3}$

Comment on the variation in the gain margin and phase margin for C(s)G(s) in comparison to the gain margin and phase margin of G(s) for the cases (a) and (b).

Q2) A “Notch filter” is a band stop filter or band-reject filter that has a very low gain at a particular frequency. Determine a transfer function of a notch filter that rejects (or attenuates) a 50 Hz signal. Comment on a method to modify (or adjust) the steepness of the magnitude plot for the notch filter and prove the same by comparing the corresponding bode plots.

Q3) For the transfer function C(s) = $\dfrac{100}{s+30}$ how much **minimum delay** (in seconds) would be needed to destabilize the **closed-loop system**. Compare the Bode plots (magnitude and phase) of C(s) and C(s)G(s) where G(s) is the delay calculated to achieve the destabilization. What can you comment on the gain and phase margins, with and without the delay?

Q4) For the given open-loop system G(s) = $\dfrac{1}{(s^3+3s^2+2s)}$, observe the difference in the gain margin magnitudes on applying the following four techniques:

i) Root-locus
ii) Nyquist plot
iii) Bode-plots: using the asymptotic plot for calculating the gain margin
iv) Bode-plots: using the actual plot for calculating the gain margin

Q5) For the given open-loop system G(s) = $\dfrac{10s+2000}{(s^3+202s^2+490s+18001)}$, perform the following operations:

i) Plot the bode plot (magnitude and phase) of the system and comment on the gain margin and phase margin of the system.
ii) Add a proportional gain ‘K’ to improve the steady-state error to 10% for the step response of the closed-loop system.
iii) Observe the new phase and gain crossover frequencies and the gain and phase margins for the system obtained in question 5 (ii).
iv) To improve the phase margin of the system obtained in question 5 (ii), cascade the open-loop system of question 5 (ii) with a zero such that the phase margin is greater than or equal to 90 degrees, but **without altering the dc gain** of the closed-loop system.
v) Comment on the closed-loop system stability for the transfer function obtained in question 5 (iv).