Control System: Homework 06 for Unit 5A, 5B, 5C: Root Locus

Assigned: Oct 28, 2022

Due: Nov 10, 2022 (23:59)

Please read the following problems and their solutions. Then, choose one of them and edit your solution for the selected problem. Submit your homework file in PDF format to the NTU-Cool website.

1. (U5B: Root Locus)

3. For the characteristic equation

$$1 + \frac{K}{s^2(s+1)(s+5)} = 0,$$

(a) Draw the real-axis segments of the corresponding root locus.

(b) Sketch the asymptotes of the locus for $K \to \infty$.

(c) Sketch the locus.

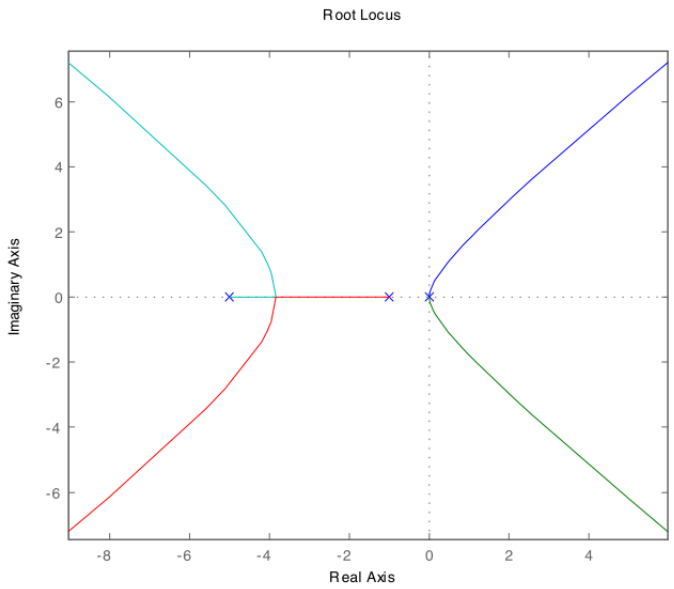
(d) Verify your sketch with a Matlab plot.

Solution:

(a) The real axis segment is $-1 > \sigma > -5$.

(b) $\alpha = -6/4 = -1.5$; $\phi_i = \pm 45°, \pm 135°$

(c) The plot is shown below.



2. (U5B: Root Locus)

4. *Real poles and zeros.* Sketch the root locus with respect to K for the equation $1+KL(s)=0$ and the listed choices for $L(s)$. Be sure to give the asymptotes and the arrival and departure angles at any complex zero or pole. After completing each hand sketch, verify your results using Matlab. Turn in your hand sketches and the Matlab results on the same scales.

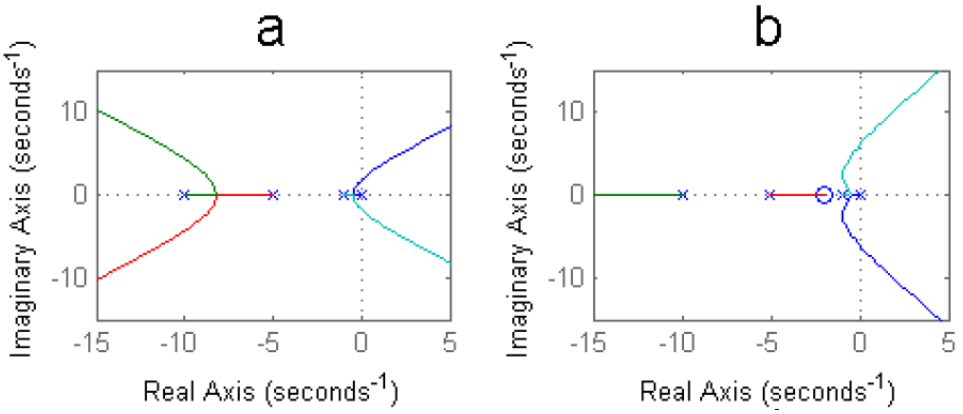
(a) $L(s) = \dfrac{2}{s(s+1)(s+5)(s+10)}$

(b) $L(s) = \dfrac{(s+2)}{s(s+1)(s+5)(s+10)}$

Solution:
All the root locus plots are displayed at the end of the solution set for this problem.

(a) $\alpha = -4$; $\phi_i = \pm 45°, \pm 135°$

(b) $\alpha = -4.67$; $\phi_i = \pm 60°, 180°$



3. (U5B: Timing Property and Root Locus)

13. For the system in Fig. 5.53,

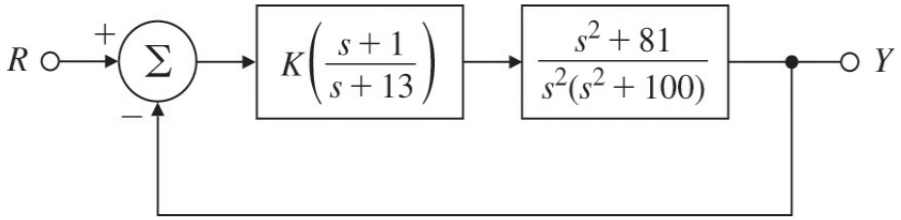


Fig. 5.53 Feedback system for Problem 5.13

(a) Find the locus of closed-loop roots with respect to K.

(b) Is there a value of K that will cause all roots to have a damping ratio greater than 0.5?

(c) Find the values of K that yield closed-loop poles with the damping ratio $\zeta = 0.707$.

(d) Use Matlab to plot the response of the resulting design to a reference step.

Solution:

(a) The locus is plotted below

(b) There is a K which will make the 'dominant' poles have damping 0.5 but none that will make the poles from the resonance have that much damping.

(c) Using rlocfind, the gain is about 35.

(d) The step response shows the basic form of a well damped response with the vibration of the response element added.