MECE 3350U
Control Systems

Lecture 22

Stability Analysis in the Frequency Domain Exercises

Videos in this lecture

Exercise 128: https://youtu.be/tRHesQXGTmk

Exercise 129: https://youtu.be/CTJin3TEkb4

Exercise 130: https://youtu.be/XWRIgzgiMhE

Exercise 131: https://youtu.be/xf-aHkhsYis

Outline of Lecture 22

By the end of today's lecture you should be able to

- Understand the connection between Bode and Nyquist plots
- Understand the connection between frequency and temporal domain
- Analyse the stability of a system in the frequency domain

This lecture has no theory, only practice exercises.

Please watch all the videos provided this lecture attentively.

Exercise 128

Given the open-loop transfer function

$$G(s) = \frac{s + 0.1}{(s+1)(s+10)(s+100)} \tag{1}$$

(a) Calculate the phase and magnitude of $G(s)$ at $\omega = 10^{-3}$ and 10^3 rad/sec

(b) Draw the Bode plot

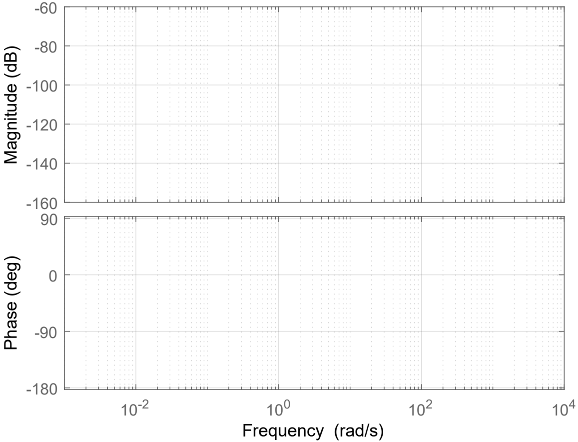
(c) Study the relation between the Bode and Nyquist plots, and the root-locus and Routh-Hurwitz array when $G(s)$ is used in an unit negative feedback loop with proportional gain k.

Exercise 128 - continued

$$G(s) = \frac{s + 0.1}{(s+1)(s+10)(s+100)}$$

Exercise 128 - continued

$$G(s) = \frac{s + 0.1}{(s + 1)(s + 10)(s + 100)}$$



Exercise 129

Given the open-loop transfer function

$$G(s) = \frac{10}{s(s^2 + 0.1s + 25)} \tag{2}$$

(a) Draw the Bode plot

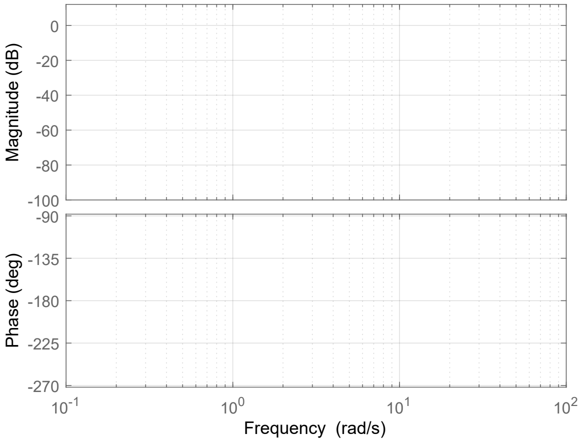
(b) Study the relation between the Bode and Nyquist plots, and the root-locus and Routh-Hurwitz array when $G(s)$ is used in an unit negative feedback loop with proportional gain k.

Exercise 129 - continued

$$G(s) = \frac{10}{s(s^2 + 0.1s + 25)}$$

Exercise 129 - continued

$$G(s) = \frac{10}{s(s^2 + 0.1s + 25)}$$



Exercise 130

Given the open-loop transfer function

$$G(s) = \frac{20}{(s+1)^2(s+10)} \tag{3}$$

(a) Draw the Bode plot

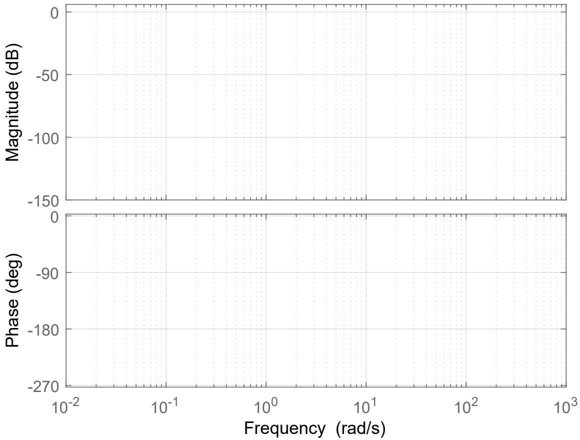
(b) Calculate the phase and gain margins

(c) Estimate the Nyquist plot and assess stability

(d) Confirm the results with the root-locus

Exercise 130 - continued

$$G(s) = \frac{20}{(s+1)^2(s+10)}$$



Exercise 130 - continued

$$G(s) = \frac{20}{(s+1)^2(s+10)}$$

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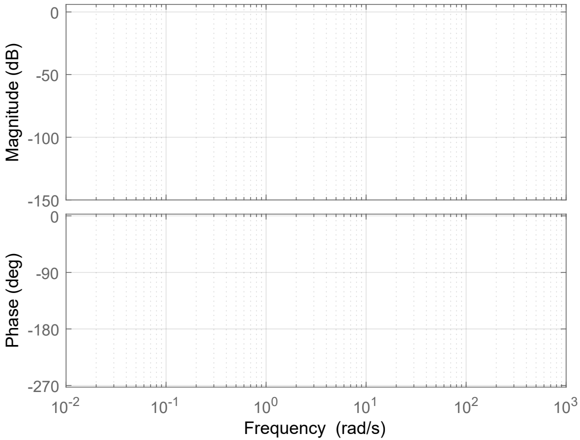
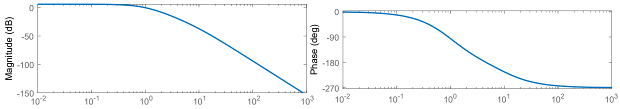
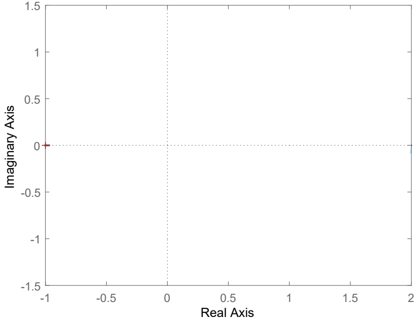
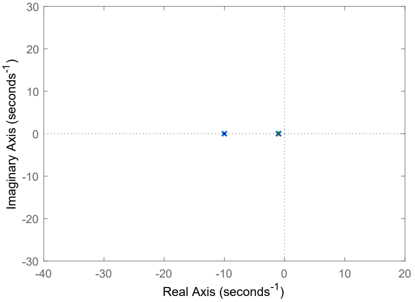


Exercise 130 - continued





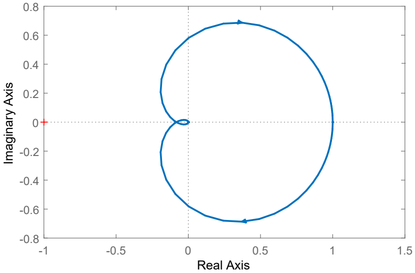
Exercise 130 - continued



Exercise 131

Given the open-loop transfer function and the corresponding Nyquist plot for $k = 1$, determine the maximum gain k before instability. Then, study the relation between the Bode and Nyquist plots, and the root-locus and Routh Hurwitz array when $G(s)$ is used in an unit negative feedback loop with proportional gain k.

$$G(s) = k\frac{100}{(s+1)^2(s+10)^2} \tag{4}$$



Exercise 131 - continued

$$G(s) = k\frac{100}{(s+1)^2(s+10)^2}$$

Exercise 131 - continued

$$G(s) = k\frac{100}{(s+1)^2(s+10)^2}$$