

XMUT315 Control Systems Engineering

Laboratory 4: Analysis with Root Locus

Due Date: Ask the XMUT co-teacher on how to submit the report.

A. Root Locus Analysis

1. You are given three control systems as listed below:

$$G_1(s) = \frac{s^2 - 12s + 27}{s^2 + 10s + 24}$$

(System 1)

$$G_2(s) = \frac{s + 2}{0.9s^3 + 3s^2 + 5s + 2}$$

(System 2)

$$G_3(s) = \frac{s^2 + 3s + 2}{s^2 - 8s + 15}$$

(System 3)

- Determine the poles and zeros of the systems and predict the characteristics of the plots based on these poles and zeros (e.g. asymptotes, breakaway/in, or angle of departure).
[15 marks]
- Calculate the breakaway/in points for the root locus and the imaginary axis intercepts for Systems 1 and 3. In the class, we discussed two techniques to calculate the breakaway/in points, attempt both methods to compare the complexity of the systems given above.
[30 marks]
- For System 2, calculate the angle of departure for complex root (instead of the breakaway/in points).
[10 marks]
- Sketch the root locus diagrams of the systems given above.
[15 marks]
- Simulate the systems in MATLAB (hint: use `rlocus()` function in MATLAB).
[7.5 marks]
- Discover any three differences that you observed between your sketch and calculation results with the simulation results and give reasons behind these differences.
[7.5 marks]

B. Nyquist Diagram Analysis

2. Given the following control systems as described with transfer functions below.

$$G_1(s) = \frac{10}{s(s^2 + 4s + 20)}$$

(System 1)

$$G_2(s) = \frac{50(s + 3)}{s(s - 2)(s + 4)}$$

(System 2)

- a. Simulate Nyquist diagram in MATLAB and briefly describe the stability of the control systems (hint: use `nyquist()` function in MATLAB). [10 marks]
- b. Describe at least two differences between Nyquist diagram with Bode plots for determining the stability of the control systems. [5 marks]

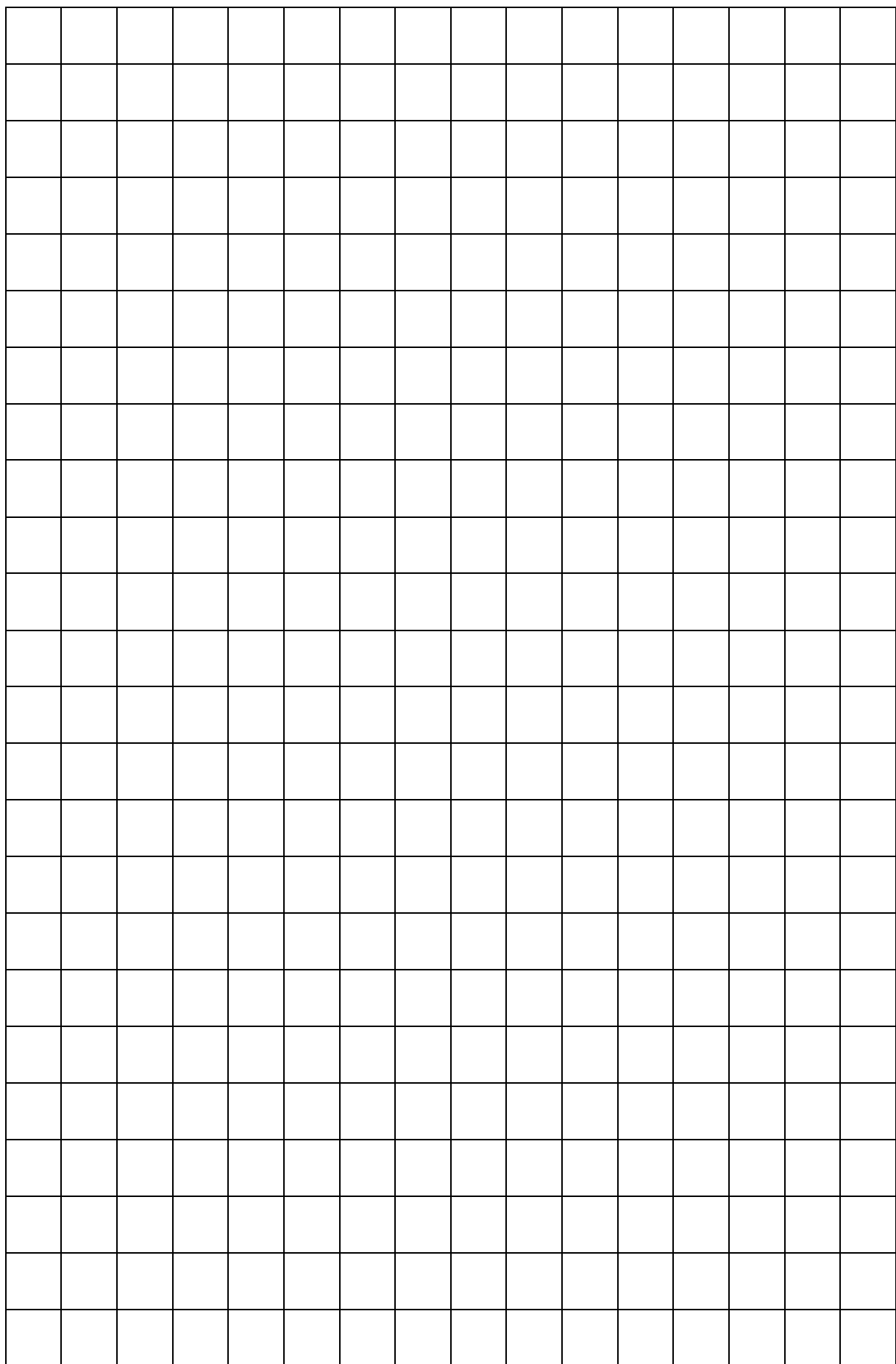
Appendix 1 – Formulae for Root Locus Analysis

Angle Asymptote in Root Locus Diagram

$$\theta_{asymptote} = \pm \frac{(2k + 1)\pi}{\#n_p - \#n_z} \quad (k = 0, \pm 1, \pm 2, \dots)$$

Real Axis Intercept in Root Locus Diagram

$$\sigma_{asymptote} = \frac{\sum_{n=1}^k (s + p_n) - \sum_{n=1}^k (s + p_n)}{\#n_p - \#n_z}$$



Marking Schedule

Student No : _____

Student Name : _____

No	Description	Mark	Your Mark	Remarks
A	Root Locus Analysis			
1a.	Poles and zeros of the systems and characteristics of the plots based on poles and zeros obtained.	15		
1b.	Break-away/break-in points and imaginary intercepts of Systems 1 and 3. Discussion of the use of two techniques for calculating break-away and break-in points.	30		
1c.	Angle of departures for complex root for System 2.	10		
1d.	Sketch of root locus diagram of the system.	15		
1e.	Root locus simulation of the system in MATLAB.	7.5		
1f.	Three differences between the sketch and calculation results with the simulation results and reasoning for their differences.	7.5		
B	Nyquist Diagram Analysis			
2a.	Nyquist diagram simulation of the system in MATLAB and brief description of the stability of the system.	10		
2b.	Two differences between Nyquist diagram and Bode plots for determining the stability of the system.	5		
	Total	100		

Comments