

## **XMUT315 Control Systems Engineering**

### **Assignment 4: Analysis with Root Locus and Nyquist Diagram**

**Due Date:** Friday, 6th June 2025 (online submission to XMUT315 wiki website at VUW)

#### **A. Root Locus Analysis**

1. Sketch root locus diagram of the following open-loop control system given below. [10 marks]

$$G(s) = \frac{(s + 5)}{(s - 0.2)(s^2 + 2s + 32)(s^2 - 125)}$$

2. Consider the following control systems having the transfer functions:

- i. System 1:

$$G_1(s) = \frac{s^2 + 4s + 5}{(s + 2)(s + 3)(s + 4)}$$

- ii. System 2:

$$G_2(s) = \frac{100(s + 6)}{s(s + 1)(s + 2)(s + 3)(s + 4)}$$

- iii. System 3:

$$G_3(s) = \frac{(s + 1)^2}{(s + 1)(s + 6)}$$

- iv. System 4:

$$G_4(s) = \frac{(s + 1)^2}{(s - 1)(s + 6)}$$

- v. System 5:

$$G_5(s) = \frac{(s + 3)}{(s + 1)(s - 1)(s + 4)}$$

- vi. System 6:

$$G_6(s) = \frac{(s + 4)}{(s + 1)(s - 1)(s + 3)}$$

- a. Sketch the root locus diagram for each of the systems. You need not calculate break in/out points, crossing points of the imaginary axis or angle of departure/arrival. However, you should indicate the real axis intercept of any asymptotes and their angles. [30 marks]
- b. With the aid of appropriate sketches, describe the closed loop step response of each system (but skip  $G_2(s)$  for now) as well as its behaviour for very large  $K$ . [25 marks]
- c. For the system described by  $G_2(s)$ , describe how the behaviour of the system changes as the compensator gain is varied over the complete range from zero to infinity. [10 marks]

### B. Nyquist Diagram Analysis

3. For the following control system given by the following transfer function

$$G(s) = \frac{20}{s^3 + 5s^2 + 6s}$$

- a. Sketch the Nyquist diagram of the system above. [15 marks]
- b. Referring to the Nyquist diagram, describe the stability of the system. [5 marks]
- c. Perform Nichols chart simulation of the system in MATLAB. Does the simulation result confirm the outcome of part (b)? [5 marks]

**Marking Schedule**

Student ID : \_\_\_\_\_

Student Name : \_\_\_\_\_

No	Description	Mark	Your Mark	Remarks
<b>A</b>	<b>Root Locus Analysis</b>			
1	Sketch of the root locus diagram of the system.	10		
2a	Sketch of root locus diagrams of the systems.	30		
2b	Description of closed-loop step response of the systems and its behaviour for very large $K$ .	25		
2c	Description of behaviour of the system as the compensator gain is varied from zero to infinity.	10		
<b>B</b>	<b>Nyquist Diagram Analysis</b>			
3a	Sketch of Nyquist diagram of the system.	15		
3b	Description of stability of the system.	5		
3c	Result of Nichols chart simulation of the system in MATLAB and its comparison with the result of part (b).	5		
	Total	100		

Comment: