XMUT315 Control Systems Engineering

Laboratory 3: Analysis with Bode Plots

Due Date: Not for submission

A. Controllers and Compensators

1. There are a number of standardised controllers and compensators in control systems (see the appendix section). You are given the open-loop transfer function of a unity feedback control system as shown below.

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

   a. Simulate the step response of the system in MATLAB and describe at least two issues experienced by the system. [10 marks]

   b. By using simulation in MATLAB, describe how any of these controllers listed below when implemented as shown in the Figure 1 below are able to influence the system.

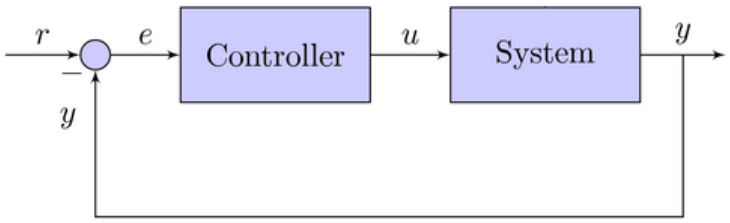


Figure 1: Feedback control system

   i. Proportional controller. [10 marks]
   ii. Derivative controller. [10 marks]
   iii. Integral controller. [10 marks]

c. Like part (b), replacing the controller with compensator, by using simulation in MATLAB, describe on how any of the compensators listed below are able to influence the system:

i. Lag compensator. [10 marks]
ii. Lead compensator. [10 marks]

B. Analysis with Bode Plots

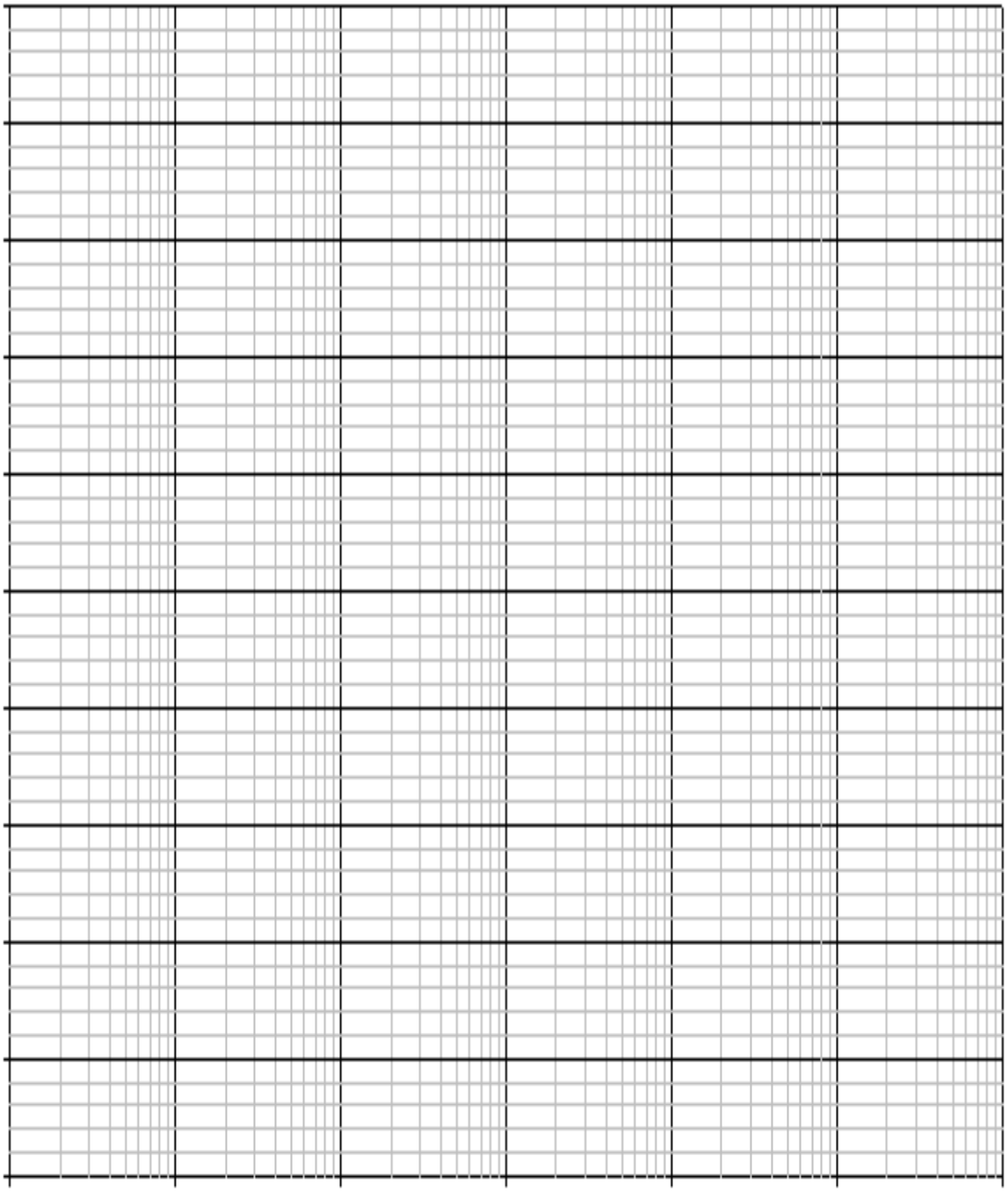
2. A system has the open-loop transfer function:

$$G(s) = -\frac{500(s - 2000)}{(s + 100)(s + 1000)}$$

a. Sketch the Bode plots of the system by hand. [15 marks]

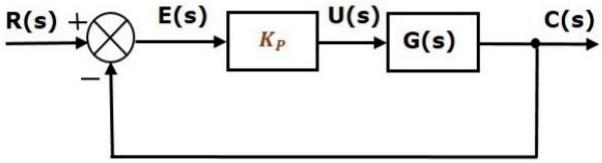
b. Simulate the Bode plots and gain and phase margin of the system in MATLAB. [10 marks]

c. From results of parts (a) and (b), what are the gain margin, phase margin and unity gain frequency of the system? The presence of the non-minimum phase zero makes this system somewhat challenging. How does the presence of this zero make things tricky? Compare and discuss the differences between results of sketching and simulation. By referring to the results that you obtained, describe at least two differences of manual sketching and simulation of the system. [15 marks]



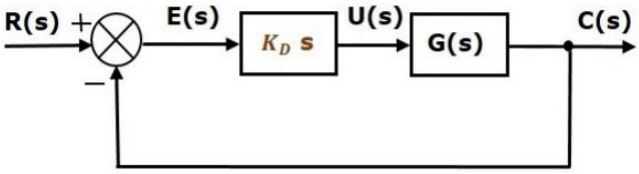
Appendix - Standardised Controllers in Control Systems

1. The proportional controller.



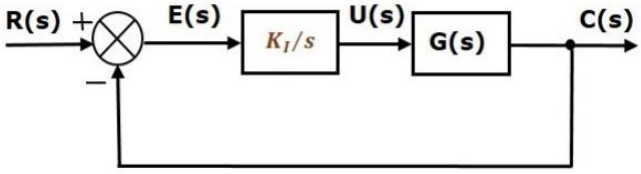
$$\frac{U(s)}{E(s)} = K_P$$

2. The derivative (phase lead) controller.



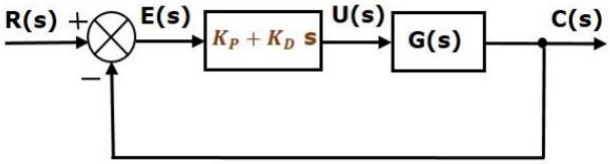
$$\frac{U(s)}{E(s)} = K_D s$$

3. The integral (phase lag) controller.



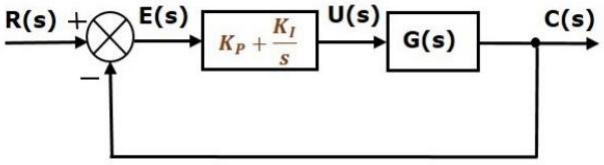
$$\frac{U(s)}{E(s)} = \frac{K_I}{s}$$

4. The proportional derivative (PD) controller.



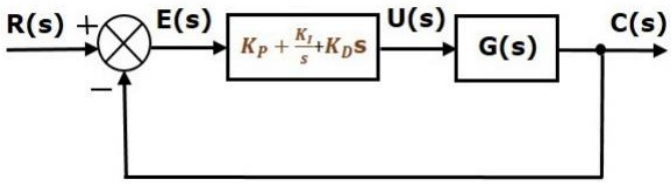
$$\frac{U(s)}{E(s)} = K_P + K_D s$$

5. The proportional integral (PI) controller.



$$\frac{U(s)}{E(s)} = K_P + \frac{K_I}{s}$$

6. The proportional integral derivative (PID) controller.



$$\frac{U(s)}{E(s)} = K_P + \frac{K_I}{s} + K_D s$$

Marking Schedule

Student No : _____

Student Name : _____

No	Description	Mark	Your Mark	Remarks
A	*Controller and Compensator:*			
1a.	Issues experienced by the system.	10		
1b.	Description and simulation in MATLAB of the influence of the following controllers:			
i.	Proportional controller	10		
ii.	Derivative controller	10		
iii.	Integral controller	10		
1c	Description and simulation in MATLAB of the influence of the following compensators:			
i	Lag compensator	10		
ii	Lead compensator	10		
B	*Analysis with Bode Plots:*			
2a.	Sketch of Bode plots of the system.	15		
2b.	Simulation of Bode plots of the system from MATLAB.	10		
2c.	Gain margin, phase margin and unity gain frequency of the system.	5		
	Reasoning for challenge due to the present of non-minimum phase zero in the system.	5		
	Comparison and two differences between manual sketching and simulation of the system.	5		
	Total	100		

Comments