



INTI
International College Penang

FINAL
Examination Paper

(COVER PAGE)

Session : August 2018

Programme : Diploma in Electrical and Electronic Engineering (DEEI)

Course : EEE2108: Modern Control Systems Engineering

Date of Examination : 6 December 2018 (Thursday)

Time : 11:00am – 1:00pm

Duration : 2 Hours Reading Time : Nil

Special Instructions :

This paper consists of SIX (6) questions. Answer any FOUR (4) questions in the answer booklet provided. All questions carry equal marks.

IMPORTANT NOTE : THIS PAPER SHOULD NOT BE TAKEN OUT OF THE EXAMINATION HALL BY THE STUDENTS.

Materials Permitted :

Non-programmable Calculator or programmable calculator (not pre-programmed)

Materials Provided :

Bode Diagram (to be attached with the answer booklet)

Examiner(s) : Alan Wong Kam Mun

Moderator : Dr. Ooi Beng Lee

This paper consists of 7 printed pages, including the cover page.

YTRARDU 11 VTR
 INTI INTERNATIONAL COLLEGE PENANG

DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING PROGRAMME (DEEI)

EEE2108: MODERN CONTROL SYSTEMS ENGINEERING

FINAL EXAMINATION: AUGUST 2018 SESSION

Instructions: This paper consists of **SIX (6)** questions. Answer any **FOUR (4)** questions in the answer booklet provided. All questions carry equal marks.

Question 1

- (a) A unity feedback control system has $G(s) = \frac{K}{s(s+4)(s+10)}$.
 Draw the Bode plot for $\omega = 1$ to 10. Find the value of K when system is marginally stable.
 (14 marks)
- (b) For $G(s)H(s) = \frac{1}{s^2(s+2)}$, sketch the Nyquist plot and determine the stability of the system based on Nyquist Stability Criteria.
 (11 marks)

Question 2

For transfer function

$$G(s) = \frac{10}{s(1+0.4s)(1+0.1s)}$$

- (a) Show the equation for magnitude $|G(s)|$ and phase of $G(s)$.
 (5 marks)
- (b) Calculate and tabulate the values of magnitude $|G(s)|$ and phase of $G(s)$ for $\omega = 1, 2, 4, 5$ and 10.
 (10 marks)
- (c) Plot the values (b) above (both magnitude and phase) on a Bode (semi-log) sheet.
 (6 marks)
- (d) Using the plot from part (c), verify the stability of the system and find the Gain margin and Phase margin respectively.
 (4 marks)

Question 3

- (a) Use the Routh-Hurwitz criteria to find how many poles of the following closed-loop system, are in the rhp (right hand pole), in the lhp (left hand pole), and on the $j\omega$ -axis.

$$T(s) = \frac{s^3 + 7s^2 - 21s + 10}{s^6 + s^5 - 6s^4 + 0s^3 - s^2 - s + 6}$$

(12 marks)

- (b) For a unity feedback system with the forward transfer function

$$G(s) = \frac{K(s + 20)}{s(s + 2)(s + 3)}$$

find the range of K to make the system stable.

(13 marks)

Question 4

- (a) For a unity feedback system with $G(s) = \frac{20(s + 2)}{s^2(s + 1)(s + 5)}$. Determine:

- (i) type of system
- (ii) the 3 error coefficients
- (iii) steady-state error for input $1 + 3t + t^2/2$

(14 marks)

- (b) Given the transfer function for the operational amplifier circuitry is:

$$\frac{V_o(s)}{V_i(s)} = \frac{-R_2 C_1 s}{(1 + R_2 C_2 s)(1 + R_1 C_1 s)}$$

Where $V_o(s)$ and $V_i(s)$ are output and input to the amplifier circuitry and

$R_1 = 100\text{k}\Omega$, $R_2 = 200\text{k}\Omega$, $C_1 = 10\mu\text{F}$ and $C_2 = 20\mu\text{F}$.

Sketch the Bode |magnitude| plot.

From the sketch, describe the characteristic of the operational amplifier circuitry.

(11 marks)

Question 5

- (a) A unity feedback system has the following forward transfer function:

$$G(s) = \frac{10(s+20)(s+30)}{s(s+25)(s+35)}$$

Is the unity feedback system stable ?

(3 marks)

Find the steady-state error for the following inputs:

- i. $15u(t)$
- ii. $15t \cdot u(t)$
- iii. $15t^2 \cdot u(t)$

(6 marks)

- (b) A unity feedback system has the following forward transfer function:

$$G(s) = \frac{K(s+12)}{(s+14)(s+18)}$$

For what range of K is system stable ?

Find the value of K to yield a 10% error in the steady state.

(8 marks)

- (c) Find the sensitivity of the steady-state error to changes in K for system of Figure Q5(c) below.

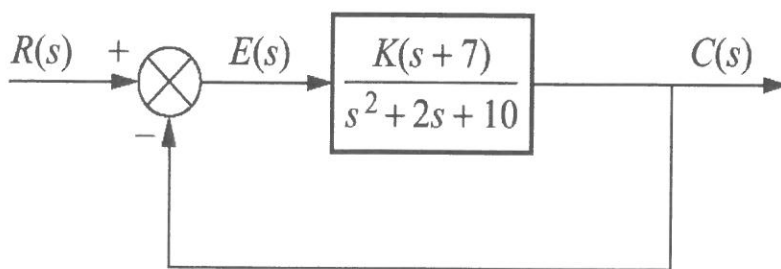


Figure Q5(c)

(8 marks)

Question 6

(a) Sketch the Nyquist diagram for the system shown in Figure Q6(a) below where

$$G(s) = \frac{1}{(s+2)(s+4)}$$

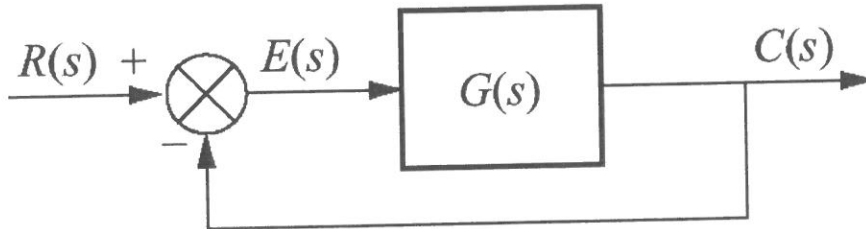


Figure Q6(a)

(8 marks)

b) The response of a unity feedback closed-loop control system with loop gain, K of 10 is plotted on the Nichols chart shown in Figure Q6(b) below:

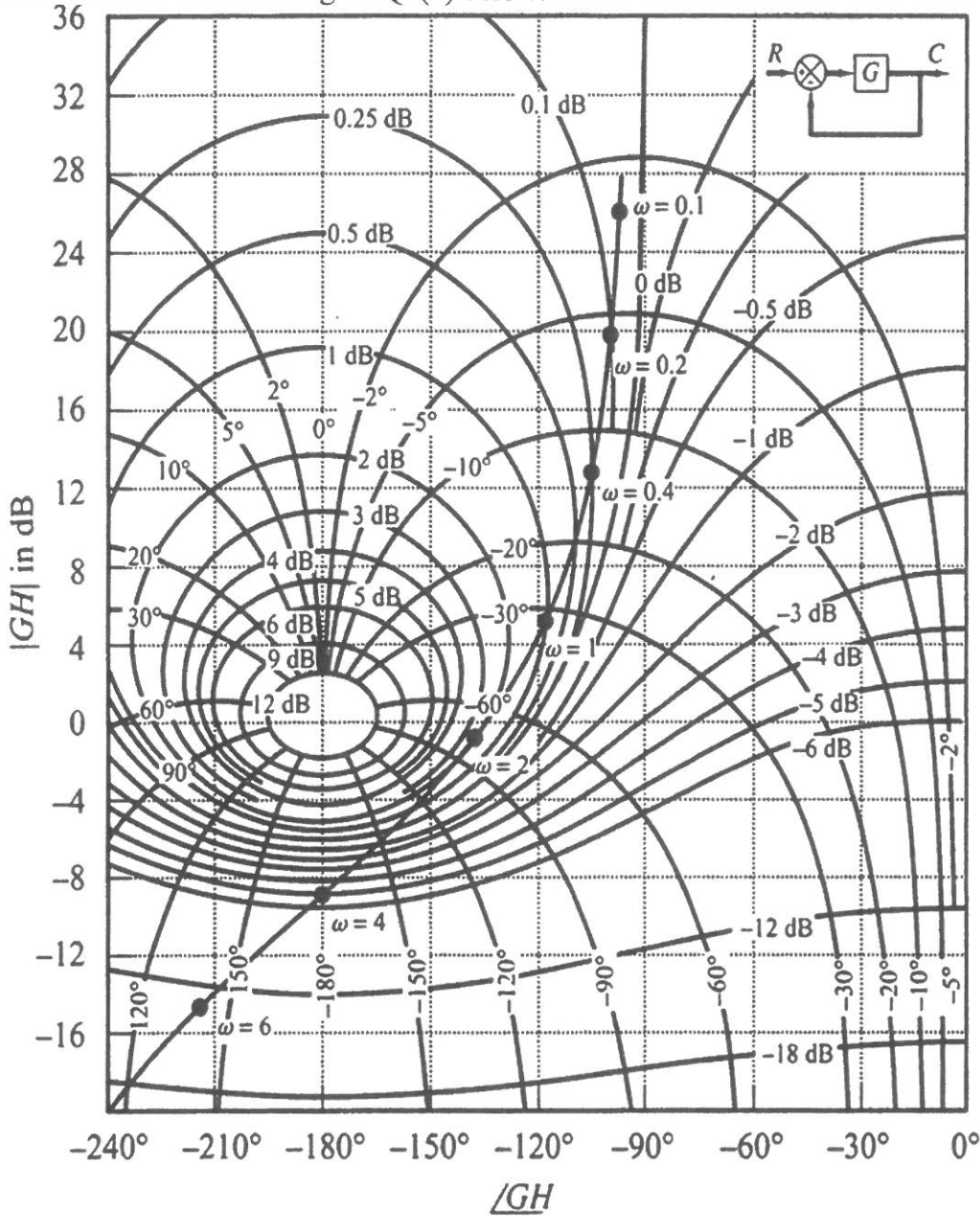


Figure Q6(b)

i) Make a table of the Open-loop and Closed-loop frequency response.

(8 marks)

Determine:

- ii) gain margin
- iii) phase margin
- iv) 3 dB bandwidth
- v) peak resonance, $M_{p\omega}$
- vi) resonant frequency, ω_r

How to increase both the gain margin and phase margin?

(9 marks)

—THE END—

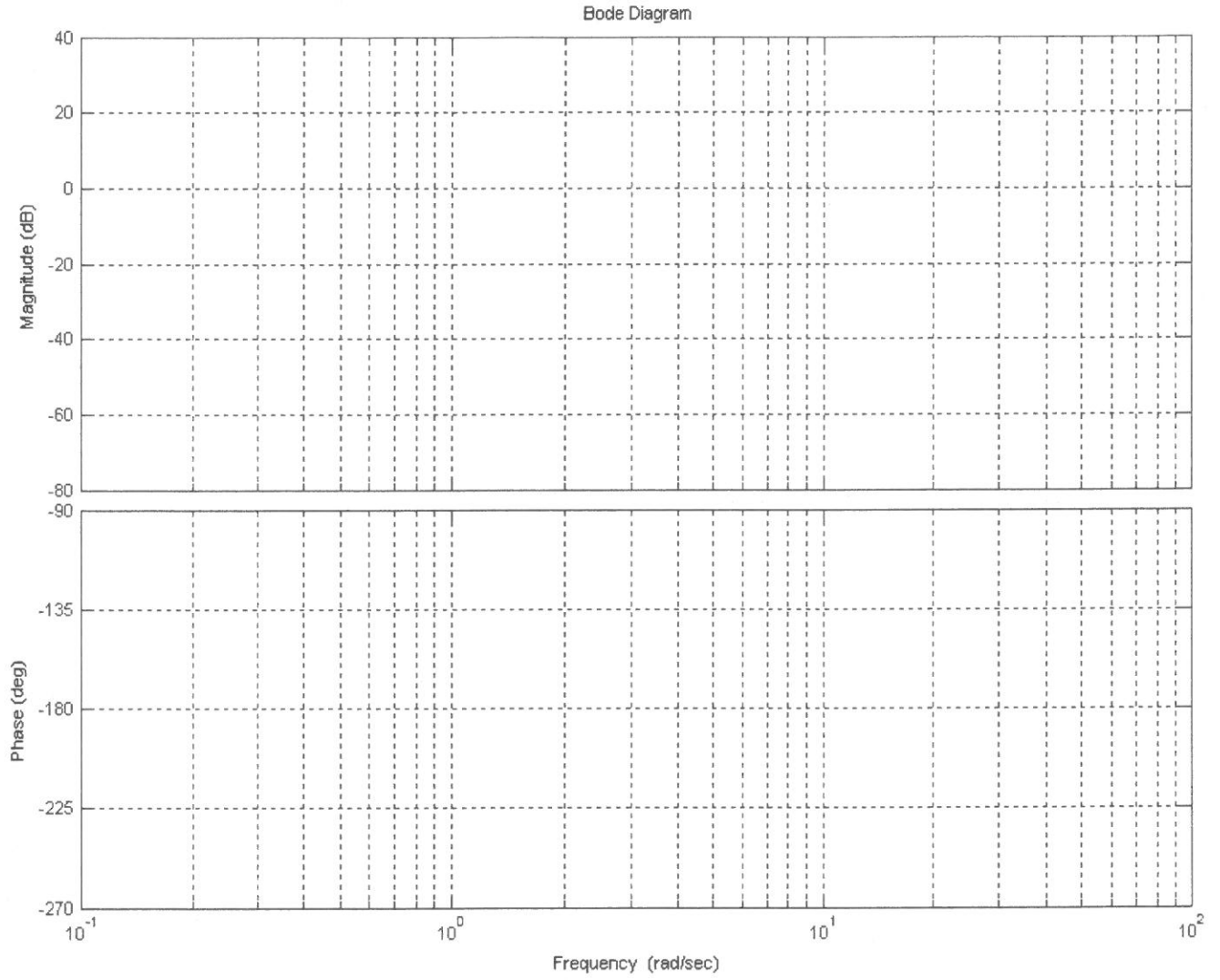
TABLE OF LAPLACE TRANSFORM

Number	$F(s)$	$f(t), t \geq 0$
1	1	$\delta(t)$
2	$1/s$	$1(t)$
3	$1/s^2$	t
4	$2!/s^3$	t^2
5	$3!/s^4$	t^3
6	$m!/s^{m+1}$	t^m
7	$1/(s + a)$	e^{-at}
8	$1/(s + a)^2$	te^{-at}
9	$1/(s + a)^3$	$\frac{1}{2!}t^2e^{-at}$
10	$1/(s + a)^m$	$\frac{1}{(m-1)!}t^{m-1}e^{-at}$
11	$\frac{a}{s(s + a)}$	$1 - e^{-at}$
12	$\frac{a}{s^2(s + a)}$	$\frac{1}{a}(at - 1 + e^{-at})$
13	$\frac{b - a}{(s + a)(s + b)}$	$e^{-at} - e^{-bt}$
14	$\frac{s}{(s + a)^2}$	$(1 - at)e^{-at}$
15	$\frac{a^2}{s(s + a)^2}$	$1 - e^{-at}(1 + at)$
16	$\frac{(b - a)s}{(s + a)(s + b)}$	$be^{-bt} - ae^{-at}$
17	$a/(s^2 + a^2)$	$\sin at$
18	$s/(s^2 + a^2)$	$\cos at$
19	$\frac{s + a}{(s + a)^2 + b^2}$	$e^{-at}\cos bt$
20	$\frac{b}{(s + a)^2 + b^2}$	$e^{-at}\sin bt$
21	$\frac{a^2 + b^2}{s[(s + a)^2 + b^2]}$	$1 - e^{-at}\left(\cos bt + \frac{a}{b}\sin bt\right)$

BODE DIAGRAM

Name: _____

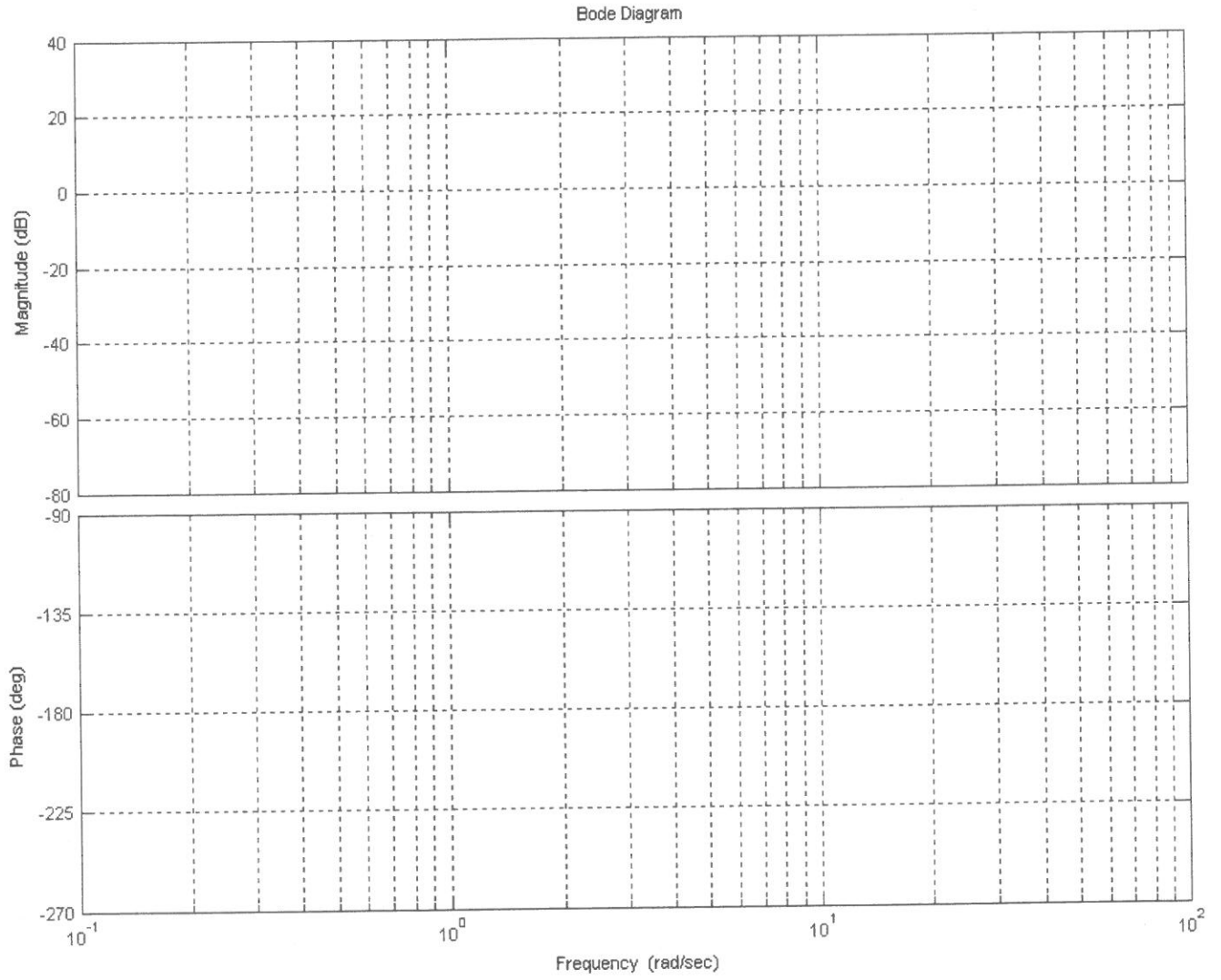
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BODE DIAGRAM

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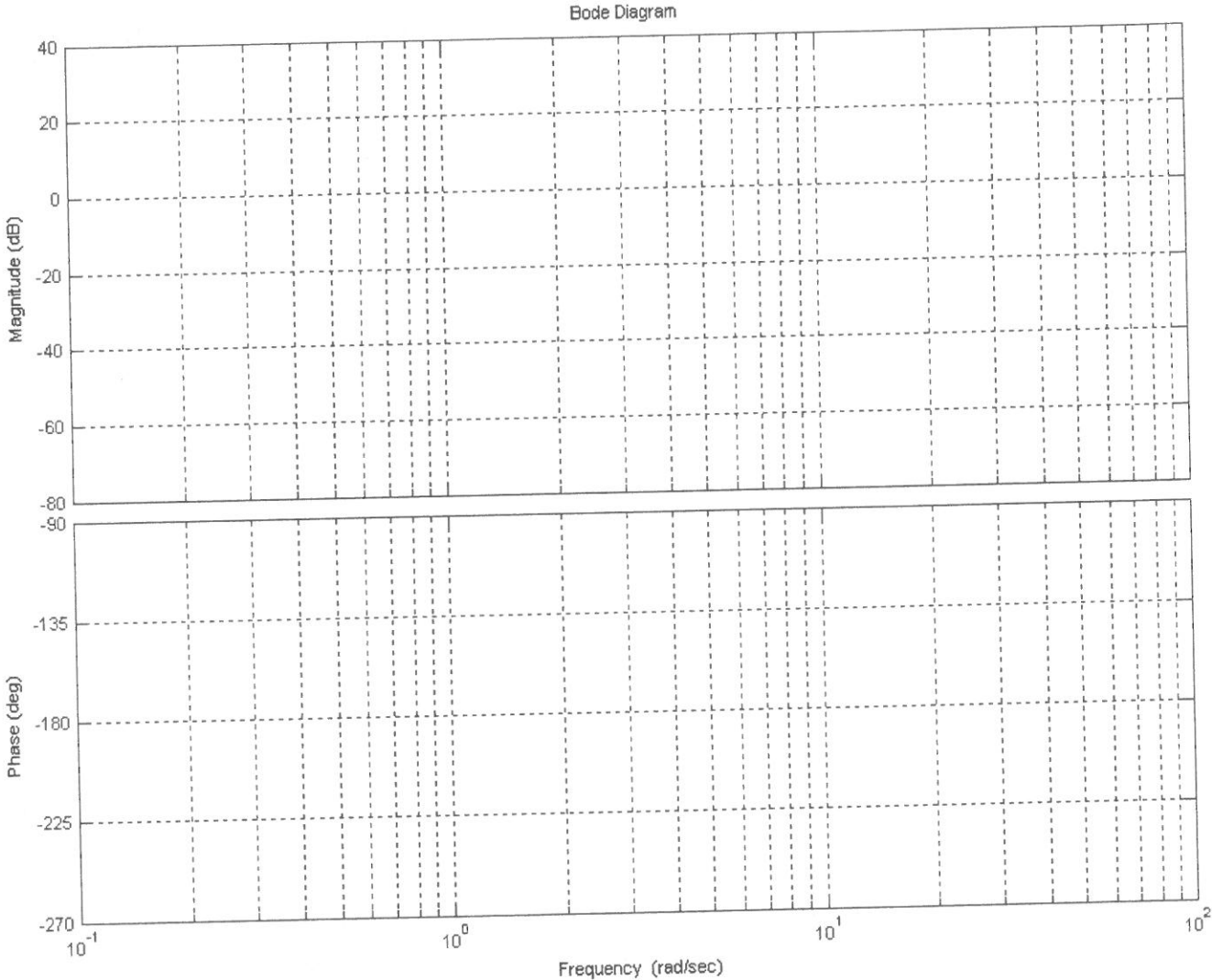
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