



**FINAL
ALTERNATIVE ASSESSMENT**

(COVER PAGE)

Session : April 2021

Programme : Diploma in Electrical & Electronic Engineering (DEEI)

Course : EEE2108: Modern Control Systems Engineering

Date of Examination : 28 July 2021 (Wednesday)

Time : 8.00am – 11.00am Reading Time : Nil

Duration : 3 Hours

Special Instructions :

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

Material permitted : Programmable Scientific Calculator

Materials provided : Nil

Examiner(s) : Alan Wong Kam Mun

Chief Moderator : Koay Ting Hoo

This paper consists of 6 printed pages, including the cover page

INTI INTERNATIONAL COLLEGE PENANG

DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING (DEEI)

EEE2108: MODERN CONTROL SYSTEMS ENGINEERING

FINAL ALTERNATIVE ASSESSMENT: APRIL 2021 SESSION

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Important notice: Computer software are **NOT** allowed in this exam except software to access the Question Paper and to submit the Answer Script. Answers are expected to be hand-written and required graph are to be manually plotted. Copy/paste of computer plotted graph will get zero marks.

Question 1

- (a) Use the Routh-Hurwitz criteria to find the number poles, of the following closed-loop system that are on the right side, on the left side and on the $j\omega$ -axis of the s -plane.

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

(15 marks)

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

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

find the range of K to make the system stable.

(10 marks)

Question 2

- (a) For the operational amplifier circuit shown in Figure Q2(a) below:

- (i) Find the transfer function, $\frac{V_o(s)}{V_i(s)}$

(6 marks)

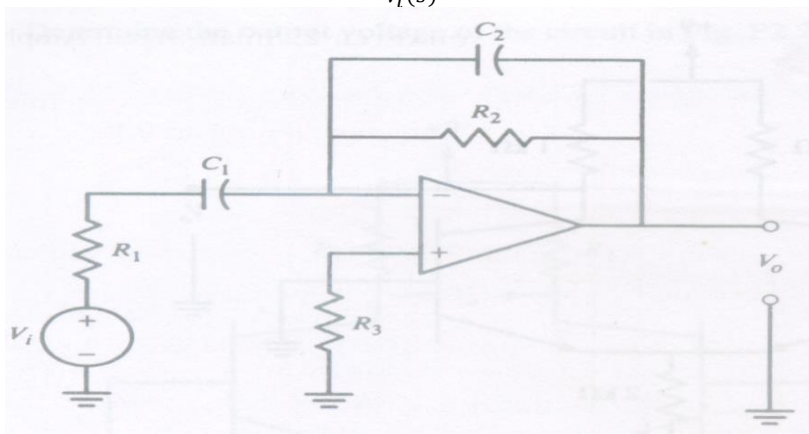


Figure Q2(a)

- (ii) Sketch the Bode |magnitude| plot, given $R_1 = 100\text{k}\Omega$, $R_2 = 200\text{k}\Omega$, $C_1 = 10\mu\text{F}$, $C_2 = 20\mu\text{F}$ and $R_3 = 0\ \Omega$. (6 marks)
- (iii) Based on the sketch from (ii) describe the type of amplifier and the range of frequency response. (3 marks)

(b) The open-loop frequency response of a unity-feedback system is given below.

ω (rad/s)	1	2	3	4	5
G dB	12.6	3.92	-2.22	-7.0	-11.0
$\angle G$ (in degree)	-127	-152	-168	-179	-188

Transfer the Open-loop frequency response data into a Nichols chart and find:

- (i) Closed-loop frequency response (tabulate in table form) (5 marks)

- (ii) Gain margin <GM> (1 mark)
- (iii) Phase margin <PM> (1 mark)
- (iv) Resonance peak <Mp> (1 mark)
- (v) Resonance frequency < ω_r > (1 mark)
- (vi) Bandwidth <BW> (1 mark)

Question 3

For unity feedback system $G(s) = \frac{k}{(s+2)(s+9)(s-1)}$

- (a) Find the number of root-locus branches. (3 marks)
- (b) Find the number of root-locus asymptotes for the behaviour at infinity. (3 marks)
- (c) Find the intersection point of the asymptotes on the real-axis. (3 marks)
- (d) Find the angles of asymptotes made with the real-axis. (3 marks)
- (e) Find the break-in and/or break-away point. (4 marks)
- (f) Find the imaginary-axis crossing points of the root-locus. (4 marks)
- (g) Draw the root-locus. (5 marks)

Question 4

(a) For the system shown in Figure Q4 (a) below with $\zeta = 0.5$, find:

- (i) Natural frequency, ω_n (3 marks)
- (ii) k-value (1 marks)
- (iii) Rise Time (3 marks)
- (iv) Peak Time (1 mark)
- (v) Maximum Overshoot (1 mark)
- (vi) Settling time for (2% error) (1 mark)

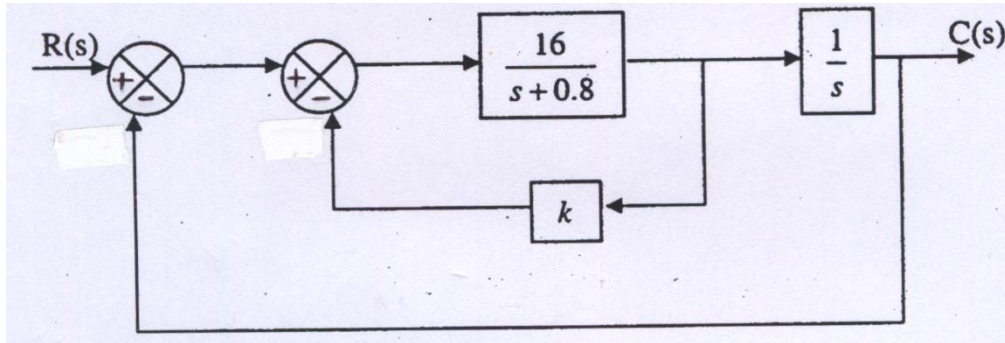


Figure Q4 (a)

(b) For a unity feedback control system, the open loop transfer function is given as:

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

Find :

(i) The position, velocity and acceleration error constants (6 marks)

(ii) The steady state error when the input is

$$R(s) = \frac{3}{s} - \frac{2}{s^2} + \frac{1}{3s^3}$$

(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	$\frac{a^2+b^2}{s[(s+a)^2+b^2]}$	$1 - e^{-at}\left(\cos bt + \frac{a}{b}\sin bt\right)$

