



FINAL
Examination Paper

(COVER PAGE)

Session : April 2019

Programme : Diploma in Electrical and Electronic Engineering (DEEI)

Course : EEE2108: Modern Control Systems Engineering

Date of Examination : 31 July 2019 (Wednesday)

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 (e.g. Model fx570 Series)

Materials Provided :
Laplace Transform Table
Formula Sheet
Linear Graph Paper (× 1)
Worksheet for Q6(b)

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Moderator : Dr. Ooi Beng Lee

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

Question 2

a. An electronic system is modeled by the equation,

$$\frac{d^2v_o(t)}{dt^2} + 9\frac{dv_o(t)}{dt} + 48v_o(t) = 96v_i(t)$$

$v_o(t)$ is the instantaneous output voltage while $v_i(t)$ is the instantaneous input voltage. Calculate the circuit's,

- i. undamped natural frequency, ω_n [3]
- ii. damping ratio, ζ [2]
- iii. damped natural frequency, ω_d [2]
- iv. unit step steady-state response. [3]

b. An electronic system is desired to attenuate its input voltage signal by half. However, in the process of designing, the actual system exhibited the following transfer function,

$$T_a(s) = \frac{2}{s^2 + 2s + 4}$$

where $T_a(s)$ is the actual system's transfer function.

Examine the steady-state error between the actual system's output and the desired system's output when responding to a unit ramp input given as,

$$v_{in}(t) = t \quad [15]$$

Question 3

a. Sketch the root locus diagram for the system shown in Figure-Q3(a). Show all your workings clearly. [10]

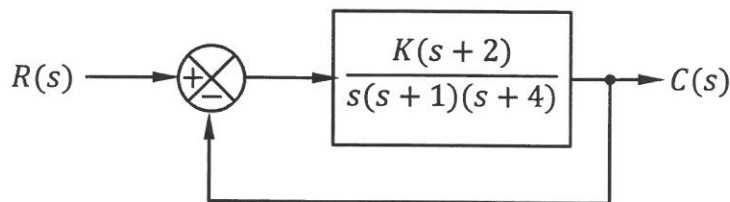


Figure-Q3(a)

b. Identify the closed-loop poles and the associated value of K for the system shown in Figure-Q3(a) such that it exhibits a closed-loop damping ratio of 0.7071. [15]

Question 4

- a. The open-loop transfer function of a unity feedback system is given as,

$$G(s) = \frac{10}{(1 + 0.5s)(1 + 0.1s)}$$

Calculate the system's phase margin.

[10]

- b. The asymptotic log-magnitude curve for an open-loop transfer function of a unity negative feedback system is given in Figure-Q4(b).

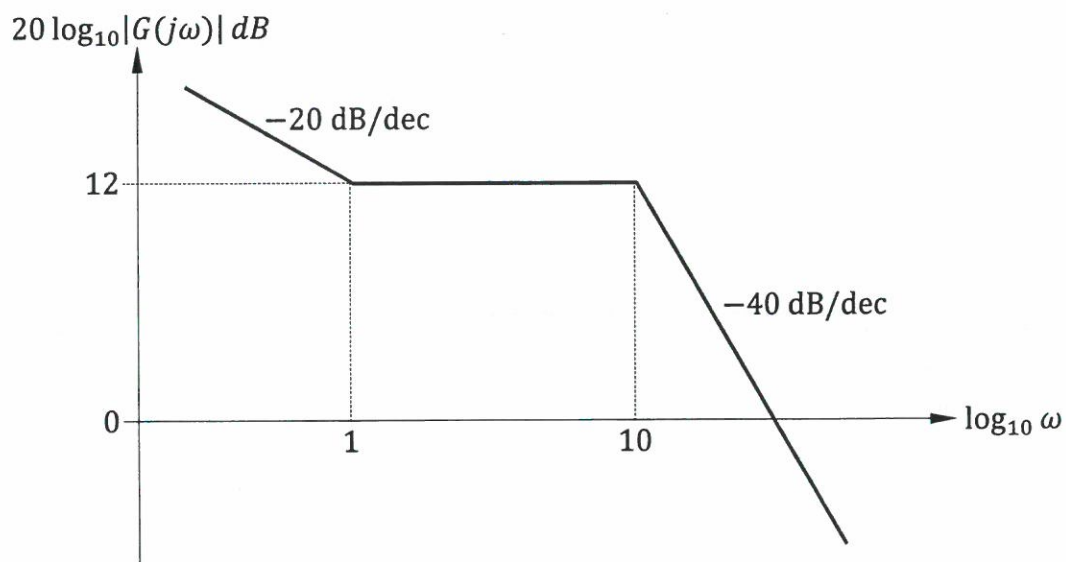


Figure-Q4(b)

- i. Identify the gain crossover frequency of the system. [3]
- ii. Identify the open-loop transfer function expression of the system in factor form. [6]
- iii. Examine the phase margin of the system. [6]

Question 5

- a. Represent the passive circuit shown in Figure-Q5(a) as a block diagram having one integral feedback and one derivative feedback. $V_{in}(t)$ is the input voltage while $I(t)$ is the circuit current response. Both the capacitor and inductor in the circuit are initially neutral. [8]



Figure-Q5(a)

- b. Figure-Q5(b) shows the root locus of a control system when its gain K varies from 0 to infinity.

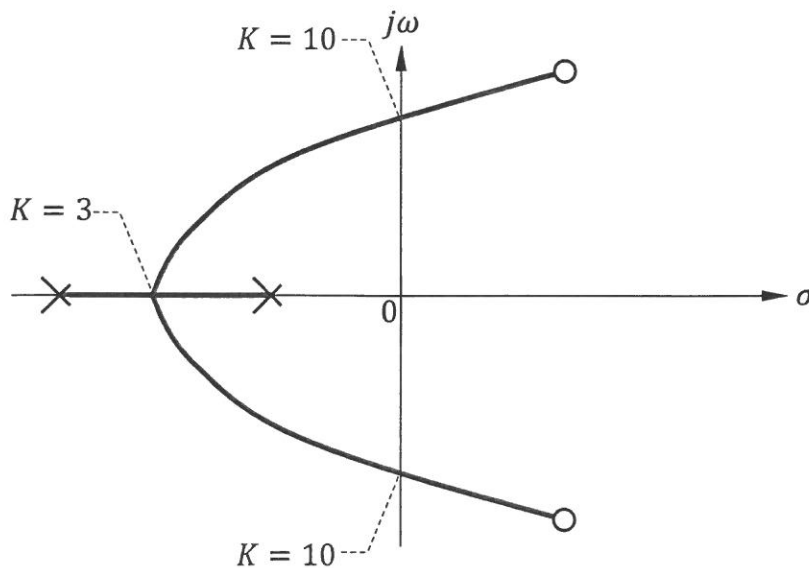


Figure-Q5(b)

- i. Identify the range of the system gain such that the system is stable and does not exhibit any underdamped response. [2]
- ii. Identify the range of the system gain such that the system is unstable. [2]
- iii. Differentiate the system's impulse responses when its gain K is set at 3.5 and 9.5 respectively. [4]

- c. The characteristic equation of a control system is,

$$s^5 + 7s^4 + 11s^3 + 2s^2 + 10s + 14 = 0$$

Determine if the system is stable.

[4]

- d. The switch in Figure-Q5(d) is turned off for a long time such that capacitor C is fully discharged. The switch is turned on again at $t = 0$ s. Express the instantaneous value of the voltage drops across the capacitor, $v_c(t)$ and thus identify the transient and steady-state expressions of $v_c(t)$ respectively. [5]

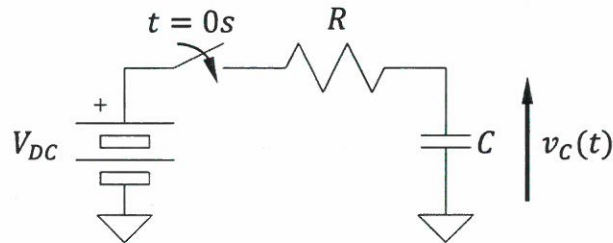


Figure-Q5(d)

Question 6

- a. The open-loop transfer function of a control system is given as,

$$G(s)H(s) = \frac{bs + 1}{bs(as + 1)^3}$$

where a and b are positive integers.

Identify the maximum value of a , expressed as a function of b , such that the system will be stable when the feedback loop is closed. [12]

- b. The open-loop transfer function of a control system is given as,

$$G(s)H(s) = \frac{2}{s(s + 1)\left(\frac{s}{3} + 1\right)}$$

- i. Complete the table given in "Worksheet for Q6(b)". [5]
- ii. Plot the Nichols chart using linear graph paper provided. [4]
- iii. Identify the phase margin of the system. [2]
- iv. Identify the gain margin of the system. [2]

~ The End ~