UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(ONLINE)
SEMESTER II
SESSION 2019/2020

COURSE NAME	:	CONTROL ENGINEERING
COURSE CODE	:	BDA30703
PROGRAMME	:	BDD
EXAMINATION DATE	:	JULY 2020
DURATION	:	5 HOURS
INSTRUCTION	:	PART A: ANSWER **ALL** QUESTIONS PART B: ANSWER **ONE (1)** QUESTION ONLY **OPEN BOOK EXAMINATION**

THIS QUESTION PAPER CONSISTS OF **FIVE (5)** PAGES

PART A: ANSWER ALL QUESTIONS

Q1 Consider the servo system for position control of an output shaft as shown in **Figure Q1**. The system consists of input device, error measuring device, amplifier, dc motor, gear train and output shaft (load). In the error measuring device, an output rotary potentiometer is used to measure the actual angular position of the output shaft. Meanwhile, the amplifier is used to amplify an electrical signal coming from the error measuring device.

(a) What is the role of error measuring device in automatic feedback control system. Describe how that role can be achieved using the electronic components depicted in the **Figure Q1**. Support your explanation with appropriate governing equations.

(5 marks)

(b) Propose a different type of sensor that can be used to realize a similar function as the rotary potentiometer used in the system. Briefly highlight the working principle of the proposed sensor. (Note: focus only on the function of the sensor without taking into consideration the practical implementation in the servo system shown in **Figure Q1**)

(5 marks)

(c) Using suitable electronic components such as operational amplifier and resistors, construct a suitable amplifier circuit with the amplification factor of 10 for the amplifier block shown in **Figure Q1**. Calculate the output coming out from the constructed circuit when subject to an input signal of 2V.

(10 marks)

Q2 Consider the system shown in **Figure Q2**, show that it can be solved by using Block Reduction Method and Mason's Gain Formula.

(a) Use block diagram reduction techniques to obtain the transfer function of the system.

(8 marks)

(b) Convert the block diagram in **Figure Q2** to Signal Flow Graph. (2 marks)

(c) Use Mason's Rule to obtain the transfer function of the system. (8 marks)

(d) What can you conclude from the transfer functions obtained in (a) and (c)?

(2 marks)

Q3 Consider the system shown in **Figure Q3**. An armature-controlled dc servomotor drives a load consisting of the moment of inertia J_L. The torque developed by the motor is T. The moment of inertia of the motor rotor is J_m. The angular displacements of the motor rotor and the load element are θ_m and θ, respectively. The gear ratio is $n = \theta/\theta_m$.

(a) Define the mathematical equations for the circuit involved. (4 marks)

(b) Define the mathematical equations for the rotational systems involved. (6 marks)

(c) Obtain the transfer function $\theta(s)/Ei(s)$. (10 marks)

Q4 Consider a unity feedback control system with closed loop transfer function and K>0:

$$\frac{C(s)}{R(s)} = \frac{Ks + 3K}{s^2 + (K+2)s + 3K}$$

(a) Determine the open loop transfer function. (4 marks)

(b) Draw the block diagram of the system in closed loop. (2 marks)

(c) Show that the steady state error in the unit ramp response is given by

$$e_{ss} = \frac{2}{3K}$$

(5 marks)

(d) Sketch root locus for such a system. Calculate the break-in dan breakaway.

(6 marks)

(e) Determine any value of K for which response of the system is not oscillatory at all.

(3 marks)

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PART B: ANSWER ONE (1) QUESTION ONLY

Q5 (a) Provide a sketch that how to measure both gain and phase margins using Bode diagram. Compare with Nyquist stability region.

(7 marks)

(b) The transfer function of an electric shredding machine system is given by;

C(s)/R(s) =200/s(2s+2)(5s+10)

(i) Sketch the Bode diagram for the system using straight line asymptote methods. (8 marks)

(ii) Determine the gain and phase margins from the Bode diagram sketched in section(b)(i). Is it system stable? (5 marks)

Q6 (a) Explain the function of Proportional controller (P), Proportional+Derivative controller (PD) and Proportional+Integral controller (PI) component in control system and state the suitable mathematic equation and graph for every controller.

(14 marks)

(b) Consider the feedback control system shown below in which a proportional compensator is employed. A specification on the control system is that the steady-state error must be less than two per cent for constant inputs.

$$G(s)=\frac{2}{(s^3+4s^2+5s+2)};D(s)=K_p$$

Use a proportional controller K_p that satisfies this specification. (6 marks)

- END OF QUESTION –

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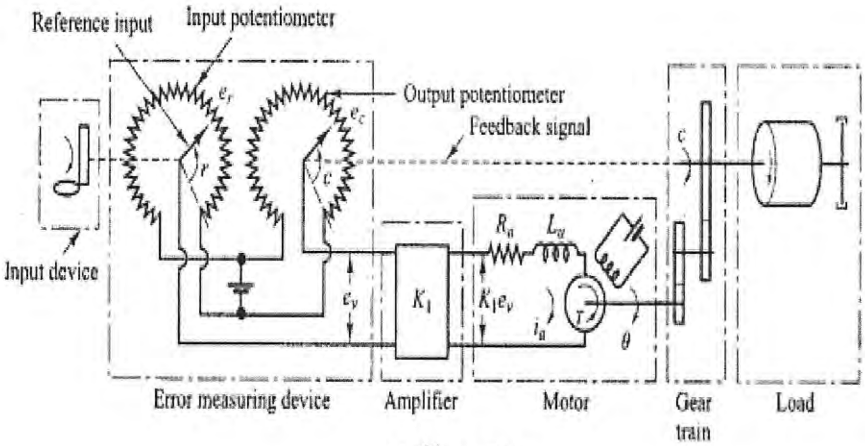

Figure Q1

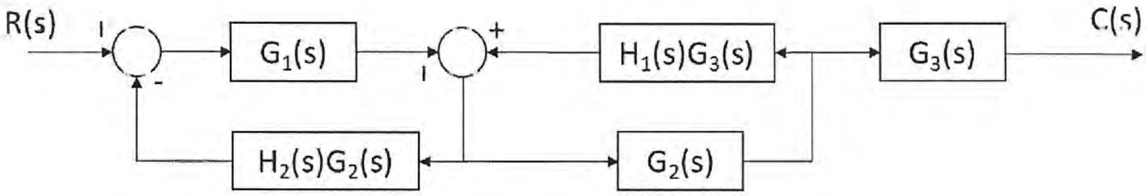

Figure Q2

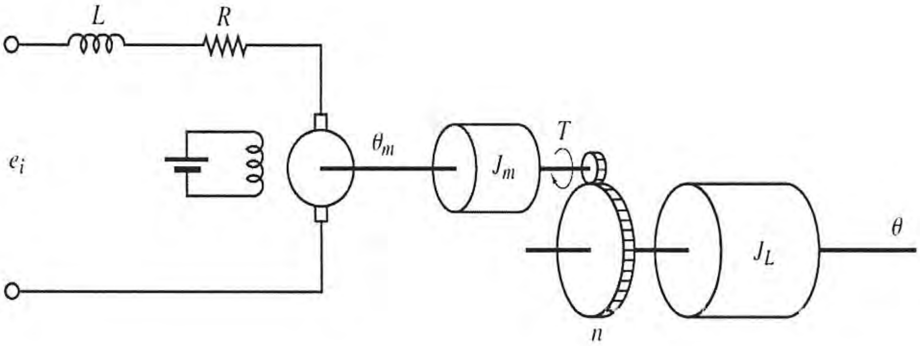

Figure Q3