[ESS25]

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

MSC SYSTEMS ENGINEERING AND ENGINEERING MANAGEMENT

SEMESTER TWO EXAMINATION 2018/2019

ADVANCED CONTROL TECHNOLOGY

MODULE NO: EEM7015

Date: Monday 20th May 2019 **Time: 10:00 – 12:00**

INSTRUCTIONS TO CANDIDATES: **There are TWO sections**

Section A - You must answer either Q1a OR Q1b from Section A

Section B - ANY TWO questions from Section B

All questions carry equal marks.

Marks for parts of questions are shown in brackets.

All working must be shown. A numerical solution to a question obtained by programming an electronic calculator will not be accepted.

School of Engineering
MSc Systems Engineering and Engineering Management
Semester Two Examination 2018/2019
Advanced Control Technology
Module No. EEM7015

SECTION A – YOU MUST ANSWER Q1(a) OR Q1(b).
PLEASE DO NOT ANSWER BOTH

Q1.

(a) For the circuit shown in Fig.1 below:

i) From Kirchhoff's current law write down the second order differential equation that describes the relationship between inductor current and the current source. **(8 marks)**

ii) Construct the state space equations and find the A, B, C and D matrices, where A, B, C, and D have their usual meaning **(12 marks)**

iii) If $R=X_L=X_C=30$ ohms for 50 Hz frequency, find the system transfer function and determine its stability from the examination of system characteristic equation. **(5 marks)**

iv) Determine the discrete-time state-space matrices A_d , B_d . **(8 marks)**

Total 33 marks

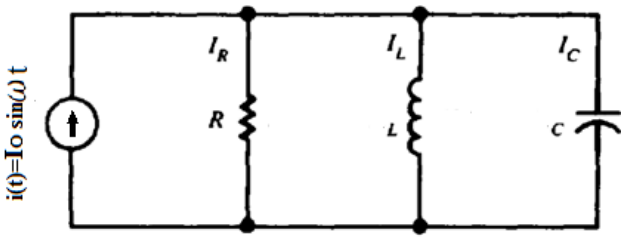

Fig.1 Parallel RLC circuit

(b) From the mass-spring-damping system of Fig. 2 shown below:

i) Write down the second order differential equation that describes the relationship between the displacement Y and the applied force F.

(8 marks)

ii) Construct the state space equations and find the A, B, C and D matrices, where A, B, C, and D have their usual meaning and

K=1 N/m, C=2 N/(m/s), M=10 N/(m/s^2) **(12 marks)**

Question 1 continues over the page….

School of Engineering
MSc Systems Engineering and Engineering Management
Semester Two Examination 2018/2019
Advanced Control Technology
Module No. EEM7015

Question 1 continued….

iii) Find the system transfer function and determine its stability from the examination of system characteristic equation. **(5 marks)**

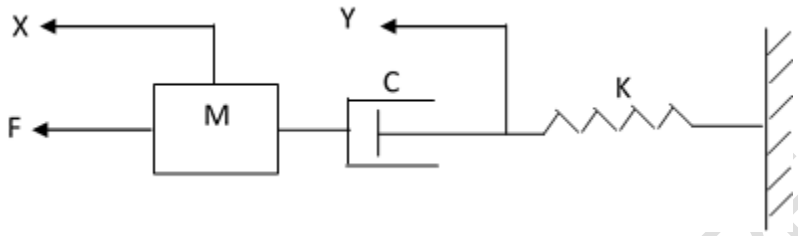

Fig.2 a mass-spring-damping system

iv) Determine the discrete-time state-space matrices A_d , B_d . **(8 marks)**

Total 33 marks

END OF SECTION A

PLEASE TURN THE PAGE FOR SECTION B…..

School of Engineering
MSc Systems Engineering and Engineering Management
Semester Two Examination 2018/2019
Advanced Control Technology
Module No. EEM7015

SECTION B – ANSWER ANY TWO QUESTIONS

Q2. A specific plant is given by

$$\dot{x} = A \cdot x + B \cdot u$$

Where $\boldsymbol{A} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -5 & -6 \end{bmatrix}$, $\boldsymbol{B} = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$

The system uses the state feedback control $\boldsymbol{u} = -\boldsymbol{K}\boldsymbol{x}$.

i) Is the system controllable? **(10 marks)**

ii) Design the regulator system shown in Fig.3 below if the desired closed-loop poles are:

$$s = -3 \mp j2,\ s = -12$$

(15 marks)

iii) Find the new transfer function of the regulated plant and prove its stability using the factorization of its characteristic equation. **(8 marks)**

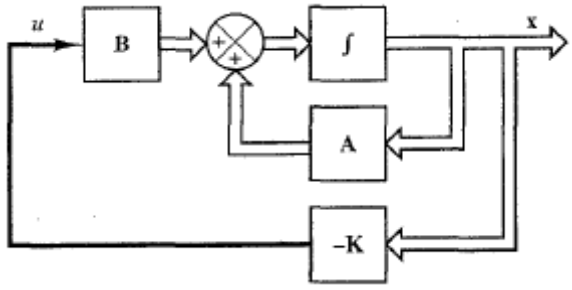

Fig.3 Regulator system

Total 33 marks

PLEASE TURN THE PAGE…..

School of Engineering
MSc Systems Engineering and Engineering Management
Semester Two Examination 2018/2019
Advanced Control Technology
Module No. EEM7015

Q3 (a) Explain the procedures of a fuzzification, a rule based evaluation, and a defuzzification. You may use examples to help and support your explanations **(9 marks)**

(b) Consider three fuzzy subsets of the set X,
X = {a, b, c, d, e, f, g} = {0, 1, 2, 3, 4, 5, 6}
referred to as A1, A2 and A3

A1 = {0.3/a, 0.4/b, 0.7/c, 0.9/d, 1.0/e, 0.3/f, 0/g}

A2 = {0.1/a, 1.0/b, 0.8/c, 0.6/d, 0.5/e, 0.3/f, 0.2/g} and

A3 = {0.8/a, 0.8/b, 0.6/c, 0.4/d, 0.3/e, 0.2/f, 0.1/g}

Conduct the following Fuzzy Set Operations:

(i) The **support** of A1, A2 and A3 **(2 marks)**

(ii) The **core** of A1, A2 and A3 **(2 marks)**

(iii) The **cardinality** of A1and A2 **(2 marks)**

(iv) The **complement** of A2 and A3 **(2 marks)**

(v) The **union** of A1, A2 and A3 **(1 mark)**

(vi) The **intersection** of A1, A2 and A3 **(1 mark)**

(vii) The new set B, if $B = A1^2$ **(1 mark)**

(viii) The new set C, if C = 0.7A2 **(1 mark)**

(ix) The new set D, for an alpha cut at $A3_{0.7}$ **(1 mark)**

(x) Defuzzyfication of the set A1 by using the central of gravity (COG) technique. **(2 marks)**

(xi) Defuzzyfication of the set A3 by using the Sugeno method. **(1 mark)**

(c) Compare and contrast Mamdani's fuzzy inference technique with the Sugeno's inference method. **(8 marks)**

Total 33 marks

PLEASE TURN THE PAGE…..

School of Engineering
MSc Systems Engineering and Engineering Management
Semester Two Examination 2018/2019
Advanced Control Technology
Module No. EEM7015

Q4 (a) Explain what frequency response is and briefly describe the merits for using frequency response to aid the design and analysis of systems. **(8 marks)**

(b) Figure Q4(b) on page 6 presents a closed loop control system with Bode plots.

(i) Identify the controller, plant and controlled plant on the plot. **(3 marks)**

(ii) Distinguish the type of the controller used and provide an equation for the controller. **(8 marks)**

(iii) Explain whether the controller has been optimised or not. **(5 marks)**

(iv) Design an improved controller on the Bode plot, to improve the performances of the system. **(9 marks)**

Question 4 continues over the page…

PLEASE TURN THE PAGE….

School of Engineering
MSc Systems Engineering and Engineering Management
Semester Two Examination 2018/2019
Advanced Control Technology
Module No. EEM7015

Question 4 continued….

You can write your answers in the Bode diagram attached. Please make sure that you have written down your ID number on the sheet.

Student ID: _____

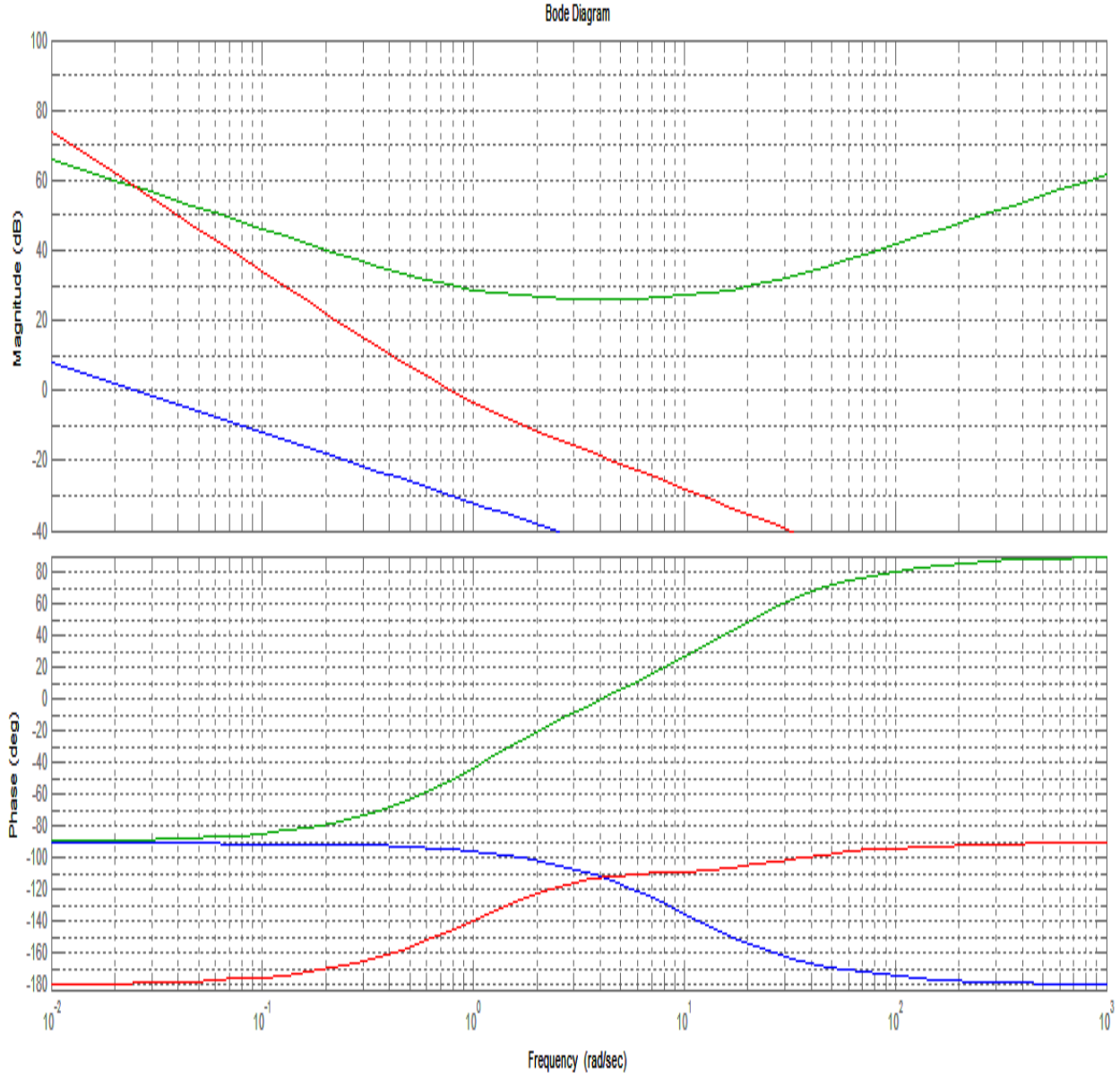

Figure Q4(b) Bode Diagrams **Total 33 marks**

END OF QUESTIONS