Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2013/2014

COURSE NAME	:	DIGITAL CONTROL
COURSE CODE	:	BEH 41503
PROGRAMME	:	BEJH
EXAMINATION DATE	:	JUNE 2014
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

Q1 (a) Solve the inverse z-transform of $X(z)=\dfrac{z(z+1)}{(z-1)(z^2+5z+6)}$ using

(i) Partial fraction method. (6 marks)

(ii) Direct division method. (6 marks)

(b) Determine the z transform of the following difference equation. Given that R(z) is unit step input and y(k)=0 for k=0,1,2,3...

$$y(k+2)+\frac{1}{4}y(k+1)-\frac{1}{8}y(k)=r(k)$$ (8 marks)

Q2 (a) Figure **Q2(a)** shows the closed loop control system.

(i) Determine the system transfer function [C(z)/R(z)]. (3 marks)

(ii) By using Jury stability theorem, analyze the range of K to make the system stable. (10 marks)

(b) Obtain the pulse transfer function for the system in Figure **Q2(b)** using signal flow. (7 marks)

Q3 Discrete control system with a sampling period T=0.1 sec is shown in Figure **Q3**. The input of the system is a unit step function.

(a) Determine the open-loop pulse transfer function of the system. (5 marks)

(b) Determine the zeros, poles and angle of asymptotes of the system. (2 marks)

(c) Formulate the root locus for the system. (13 marks)

Q4 (a) Consider the digital control system in Figure **Q4**. Construct the state space representation in the controllable canonical form.

(6 marks)

(b) Based on answer from Q4(a).

(i) Deduce the controllability and observability of the system.

(3 marks)

(ii) Design a system using pole placement method. Given that the desired eigenvalues are $z = 1 + j0.819$ and $z = 1 - j0.819$.

(8 marks)

(iii) Draw the block diagram of closed loop system for the question Q4(b)(ii).

(3 marks)

Q5 The block diagram of a digital control system is shown in Figure **Q5**.

(a) Design a dead-beat controller, $GD(z)$ when the reference input is unit step. The plant of the system is given as

$$G(z) = \frac{0.212z^{-1}\left(1 + 0.9352z^{-1}\right)}{\left(1 - 0.8187z^{-1}\right)\left(1 - 0.6067z^{-1}\right)}$$

(16 marks)

(b) Determine the steady state error of the system.

(4 marks)

- END OF QUESTION –

FINAL EXAMINATION

SEMESTER/SESSION : SEM II/2013/2014 PROGRAMME : 4 BEJ
COURSE NAME : DIGITAL CONTROL COURSE CODE : BEH 41503

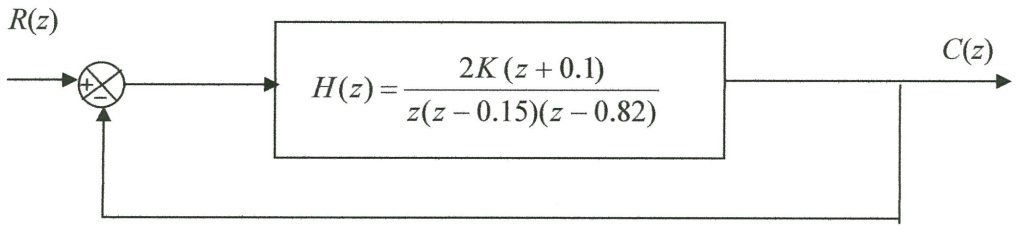

FIGURE Q2(a)

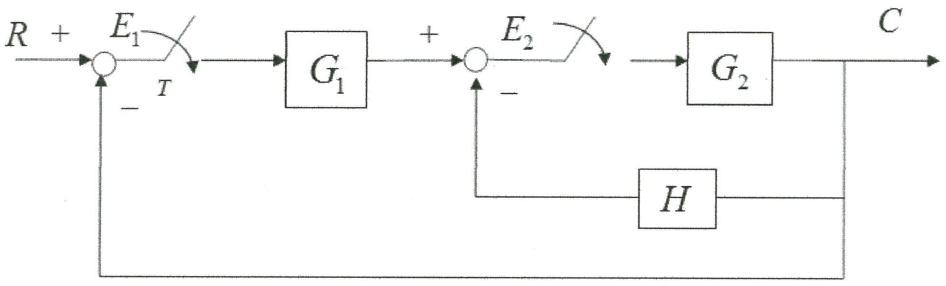

FIGURE Q2(b)

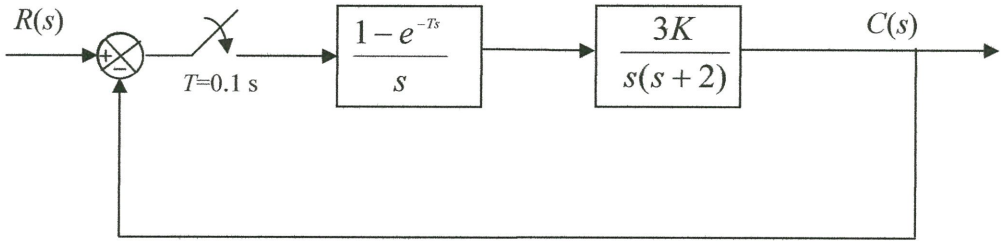

FIGURE Q3

FINAL EXAMINATION

SEMESTER/SESSION : SEM II/2013/2014 PROGRAMME : 4 BEJ
COURSE NAME : DIGITAL CONTROL COURSE CODE : BEH 41503

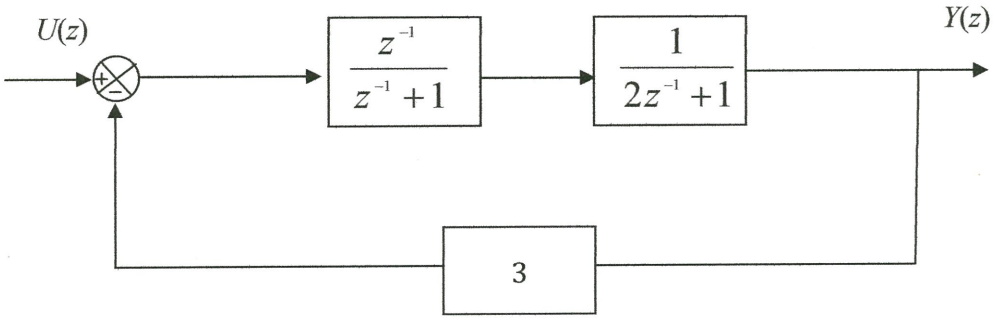

FIGURE Q4

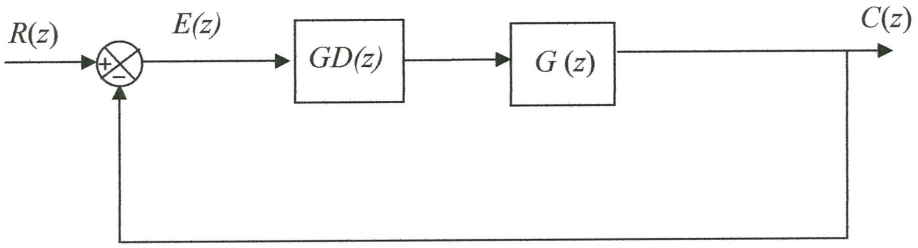

FIGURE Q5

FINAL EXAMINATION

SEMESTER/SESSION : SEM II/2013/2014 PROGRAMME : 4 BEJ
COURSE NAME : DIGITAL CONTROL COURSE CODE : BEH 41503

TABLE 1: z-transforms of $x(k+m)$ and $x(k-m)$

Discrete function	z Transform
$x(k+4)$	$z^4X(z) - z^4x(0) - z^3x(1) - z^2x(2) - zx(3)$
$x(k+3)$	$z^3X(z) - z^3x(0) - z^2x(1) - zx(2)$
$x(k+2)$	$z^2X(z) - z^2x(0) - zx(1)$
$x(k+1)$	$zX(z) - zx(0)$
$x(k)$	$X(z)$
$x(k-1)$	$z^{-1}X(z)$
$x(k-2)$	$z^{-2}X(z)$
$x(k-3)$	$z^{-3}X(z)$
$x(k-4)$	$z^{-4}X(z)$

FINAL EXAMINATION

SEMESTER/SESSION : SEM II/2013/2014 PROGRAMME : 4 BEJ
COURSE NAME : DIGITAL CONTROL COURSE CODE : BEH 41503

TABLE 2: Table of z-transforms

	$X(s)$	$x(t)$	$x(kT)$ or $x(k)$	$X(z)$
1.	—	—	Kronecker delta $\delta_0(k)$ $1, \quad k = 0$ $0, \quad k \neq 0$	1
2.	—	—	$\delta_0(n-k)$ $1, \quad n = k$ $0, \quad n \neq k$	z^{-k}
3.	$\frac{1}{s}$	$1(t)$	$1(k)$	$\frac{1}{1-z^{-1}}$
4.	$\frac{1}{s+a}$	e^{-at}	e^{-akT}	$\frac{1}{1-e^{-aT}z^{-1}}$
5.	$\frac{1}{s^2}$	t	kT	$\frac{Tz^{-1}}{(1-z^{-1})^2}$
6.	$\frac{2}{s^3}$	t^2	$(kT)^2$	$\frac{T^2z^{-1}(1+z^{-1})}{(1-z^{-1})^3}$
7.	$\frac{6}{s^4}$	t^3	$(kT)^3$	$\frac{T^3z^{-1}(1+4z^{-1}+z^{-2})}{(1-z^{-1})^4}$
8.	$\frac{a}{s(s+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z^{-1}}{(1-z^{-1})(1-e^{-aT}z^{-1})}$
9.	$\frac{b-a}{(s+a)(s+b)}$	$e^{-at}-e^{-bt}$	$e^{-akT}-e^{-bkT}$	$\frac{(e^{-aT}-e^{-bT})z^{-1}}{(1-e^{-aT}z^{-1})(1-e^{-bT}z^{-1})}$
10.	$\frac{1}{(s+a)^2}$	te^{-at}	kTe^{-akT}	$\frac{Te^{-aT}z^{-1}}{(1-e^{-aT}z^{-1})^2}$
11.	$\frac{s}{(s+a)^2}$	$(1-at)e^{-at}$	$(1-akT)e^{-akT}$	$\frac{1-(1+aT)e^{-aT}z^{-1}}{(1-e^{-aT}z^{-1})^2}$

FINAL EXAMINATION

SEMESTER/SESSION : SEM II/2013/2014 PROGRAMME : 4 BEJ
COURSE NAME : DIGITAL CONTROL COURSE CODE : BEH 41503

TABLE 2 (Continued)

	$X(s)$	$x(t)$	$x(kT)$ or $x(k)$	$X(z)$
12.	$\frac{2}{(s+a)^3}$	t^2e^{-at}	$(kT)^2e^{-akT}$	$\frac{T^2e^{-aT}(1+e^{-aT}z^{-1})z^{-1}}{(1-e^{-aT}z^{-1})^3}$
13.	$\frac{a^2}{s^2(s+a)}$	$at-1+e^{-at}$	$akT-1+e^{-akT}$	$\frac{[(aT-1+e^{-aT})+(1-e^{-aT}-aTe^{-aT})z^{-1}]z^{-1}}{(1-z^{-1})^2(1-e^{-aT}z^{-1})}$
14.	$\frac{\omega}{s^2+\omega^2}$	$\sin\omega t$	$\sin\omega kT$	$\frac{z^{-1}\sin\omega T}{1-2z^{-1}\cos\omega T+z^{-2}}$
15.	$\frac{s}{s^2+\omega^2}$	$\cos\omega t$	$\cos\omega kT$	$\frac{1-z^{-1}\cos\omega T}{1-2z^{-1}\cos\omega T+z^{-2}}$
16.	$\frac{\omega}{(s+a)^2+\omega^2}$	$e^{-at}\sin\omega t$	$e^{-akT}\sin\omega kT$	$\frac{e^{-aT}z^{-1}\sin\omega T}{1-2e^{-aT}z^{-1}\cos\omega T+e^{-2aT}z^{-2}}$
17.	$\frac{s+a}{(s+a)^2+\omega^2}$	$e^{-at}\cos\omega t$	$e^{-akT}\cos\omega kT$	$\frac{1-e^{-aT}z^{-1}\cos\omega T}{1-2e^{-aT}z^{-1}\cos\omega T+e^{-2aT}z^{-2}}$
18.			a^k	$\frac{1}{1-az^{-1}}$
19.			a^{k-1} $k=1,2,3,\ldots$	$\frac{z^{-1}}{1-az^{-1}}$
20.			ka^{k-1}	$\frac{z^{-1}}{(1-az^{-1})^2}$
21.			k^2a^{k-1}	$\frac{z^{-1}(1+az^{-1})}{(1-az^{-1})^3}$
22.			k^3a^{k-1}	$\frac{z^{-1}(1+4az^{-1}+a^2z^{-2})}{(1-az^{-1})^4}$
23.			k^4a^{k-1}	$\frac{z^{-1}(1+11az^{-1}+11a^2z^{-2}+a^3z^{-3})}{(1-az^{-1})^5}$
24.			$a^k\cos k\pi$	$\frac{1}{1+az^{-1}}$
25.			$\frac{k(k-1)}{2!}$	$\frac{z^{-2}}{(1-z^{-1})^3}$
26.		$\frac{k(k-1)\cdots(k-m+2)}{(m-1)!}$		$\frac{z^{-m+1}}{(1-z^{-1})^m}$
27.			$\frac{k(k-1)}{2!}a^{k-2}$	$\frac{z^{-2}}{(1-az^{-1})^3}$
28.	$\frac{k(k-1)\cdots(k-m+2)}{(m-1)!}a^{k-m+1}$			$\frac{z^{-m+1}}{(1-az^{-1})^m}$