LEAD CITY UNIVERSITY, IBADAN
FACULTY OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING
SEMESTER/SESSION: 2nd SEMESTER, 2022/2023

Course Particulars

Course Code: EEE 512
Course Title: Modern Control Engineering
Course Unit: 3
Course Status: Compulsory

Lecturer's Details

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Area of Specialization

Pattern Recognition, Control Engineering, Analogue and Digital Electronics Engineering

Learning Objectives of this Course

- To develop block diagrams of a digital control system including sampling and holding devices.
- To use the z transform to develop pulse transfer functions of discrete-time systems
- To develop open-loop and closed-loop transfer functions in the z domain for simple digital control systems.
- To evaluate stability of linear discrete-time systems.
- To obtained the discrete-time state-space model.
- To constructed a complete discrete-time PID controller:

Lecture Delivery Method

- Lectures with interactive sessions
- Solutions to examples problems

Course Modules

- Module 1: **Sampled Data Systems**
- Module 2: **Analysis of the Discrete Time Systems**
- Module 3: **The State-Variable of Discrete Time System**
- Module 4: **Design of Discrete Time Controller and Introduction to machine learning Control system**

LECTURE PLAN

WEEK	Topic
Module 1: Sampled Data Systems	
Week 1	Introduction
Week 2	Data Sampling
Week 3	The *Z* Transform
Week 4	Continuous Assessment /Test
Module 2: Analysis of the Discrete Time Systems	
Week 5	Difference Equations and Response
Week 6	Pulse Transfer Function
Week 7	Stability of linear discrete-time systems based on a bilinear transformation
Week 8	Continuous Assessment /Test
Module 3: The State-Variable of Discrete Time System	
Week 9	Discrete-Time State-Space model of the system
Week 10	Discrete-Time State Model from Continuous-Time Model
Week 11	The state-transition matrix and transfer matrix
Week 12	Continuous Assessment /Test
Module 4: Design of Discrete Time Controller and Introduction to machine learning Control system	
Week 11	The Discrete Time PID Controller
Week 12 Week 13	Introduction to machine learning Control system
Week 14	Revision

Grading/ Assessment

Attendance - 10 marks
Assignment/Term Paper - 10 marks
Mid-semester Test - 20 marks
Examination - 60 marks

References

1. Ashish Tewari, Indian Institute of Technology, Kanpur; Modern Control Design with MATLAB and SIMULINK, India, John Wiley & Sons, Ltd
2. Arthur G.O. Mutambara; Design and Analysis of Control Systems, CRC Press Boca Raton London New York Washington, D.C.
3. Bohdan T. Kulakowski, John F. Gardner, and J. Lowen Shearer; Dynamic Modeling and Control of Engineering Systems, Third Edition, Cambridge University Press

EEE 512- Tutorial Questions

Q1) A continuous-time signal

$$r(t) = 2\sin 4t + \cos 2t$$

is sampled at a sampling rate of 10 *rad/sec* using a ZOH. If the sampling starts at the time when $t = 0$, determine the sampling interval T, sample rate in samples per sec and the sampled value when $t = 4sec$.

Q2) Consider the difference equation in which the forcing function is exponential

$$\frac{1}{4}u(k) - \frac{1}{2}u(k-1) + \frac{1}{4}u(k-2) = \left(\frac{1}{2}\right)^k$$

If $u(-1) = 1$ and $u(-2) = 0$, determine $u(k), u(0)$ and $u(2)$

Q3) Consider the difference equation

$$20\,u(k) - 19\,u(k-1) + 5.5\,u(k-2) - 0.5\,u(k-3) = 0$$

with $u(-1) = 5$, $u(-2) = 11$, and $u(-3) = 13$. Determine the characteristic equation, characteristic roots, and the homogeneous solution and $u(7)$.

Q4) Consider the following homogeneous difference equation

$$12\,u(k) - 7\,u(k-1) + 3\,u(k-2) - u(k-3) = 0$$

with initial conditions $u(-1) = 0.5, u(-2) = 0.7$, and $u(-3) = 0.4$. Determine the characteristic equation, characteristic roots, and the homogeneous solution $u(1)$ and $u(2)$.

Q5) Find *z* transforms of the following functions.

(i) a^k and A^k

(ii) $f(t) = \cos \omega t$

(iii) $f(t) = \sin \omega t$

Q6) Find *z* transforms of the following functions.

(i) $f(t) = e^{-at}$

(ii) $f(t) = t.u_s(t)$

(iii) $x(k) = a^{kT}$

Q7) Find the inverse *z* transform of the function

$$\mathbf{F}(z) = \frac{z(z+1)}{(z^2 - 1.4z + 0.48)(z-1)}$$

Q8) Find the inverse *z* transform of the function

$$\mathbf{F}(z) = \frac{z(z+2)}{(z-1)^2}$$

Q9) Given

$$R(z) = \frac{z}{z-0.2} \qquad |z| > 0.2$$

Determine $r(0), r(1), r(2)$ and $r(3)$

Q10) Use the method of partial fractions to calculate the inverse of

$$Y(z) = \frac{4z}{z^2 - 1}$$

Determine $y(0), y(1), y(2)$ and $y(5)$

Q11) The input-output relationship of a certain discrete-time system is given by the difference equation

$$u(k) - 4u(k-1) + 3u(k-2) = r(k) - 3r(k-1)$$

give an expression for its pulse transfer function using the q variable.

Q12) Consider the following input-output relationship for an open loop discrete-time system

$$u(k) - 4u(k-1) + 3u(k-2) = r(k) - 3r(k-1)$$

Determine the poles of the closed-loop system with unity feedback.

Q13) A system is described by a discrete-time transfer function

$$G(z) = \frac{0.5(z+0.5)}{z^2 - 1.5z + 0.5}$$

Determine the system response $y(k)$ to a series of unit step inputs $u(.)$

Q14) Derive the state description of the system with the following transfer function

$$G(z) = \frac{0.5(z+1)}{(z-1)^2}$$

Q15) The continuous-time state-space description of a system is given by

$$\dot{x}(t) = Ax(t) + Bu(t)$$

$$y(t) = Cx(t) + Du(t)$$

where

$$A = \begin{bmatrix} 2 & 4 \\ 1 & 5 \end{bmatrix}, \quad B = \begin{bmatrix} 1.0 \\ 2.0 \end{bmatrix}, \; C = \begin{bmatrix} 1 & 1 \end{bmatrix}, \; D = 0$$

Give the corresponding discrete-time state-space description of this system using a sampling interval of 0.001sec.

Q16) Determine whether the discrete-time system with z-transfer function

$$D(z) = \frac{8z^3 - 3z^2 + z}{z^3 + 0.4z^2 - 0.25z - 0.1}$$

is stable or not.