GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRICAL & ELECTRONICS ENGINEERING (08)

DIGITAL CONTROL SYSTEM

SUBJECT CODE: 2160807

B.E. 6th SEMESTER

Type of course: Engineering Automation & Modern Electrical Control

Prerequisite: Fundamentals of Control Theory

Rationale: To grasp the significance of modern developments, a strong foundation is necessary in analysis, design and stability procedures applied to continuous-time linear and nonlinear feedback control systems. Simultaneously, knowledge of the corresponding methods in the digital version of control systems is also required because of the use of microprocessors, programmable logic devices and DSP chips as controllers in modern systems. This course provides systematic approach for the vital theories required for appreciating the past and present status of control engineering.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
				Theory Marks			Practical Marks			
L	T	P	C	ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
4	0	2	6	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs.	% Wtg.
1.	**Introduction:** Control System Terminology, Computer-Based Control: History and Trends, Control Theory: History and Trends, An Overview of the Classical Approach to Analog Controller Design	**6**	**12**
2.	**Signal Processing in Digital Control:** Configuration of the Basic Digital Control Scheme, Principles of Signal Conversion, Discrete-Time Signals, Time-Domain Models for Discrete-Time Systems, The z-Transform, Transfer Function Models, Frequency Response, Stability on the z-Plane and the Jury Stability Criterion.	**8**	**16**
3.	**Sample-and-Hold Systems:** The Sampling operation, The Hold operation, Practical Sample-and-Hold Circuit, Sampled Spectra and Aliasing, Reconstruction of Analog Signals, Practical Aspects of the Choice of Sampling Rate, Principles of Discretization	**7**	**14**
4.	**Models of Digital Control Devices and Systems:** z-Domain Description of Sampled Continuous-Time Plants, z-Domain Description of Systems with Dead-Time, Implementation of Digital Controllers, Tunable PID Controllers, Digital Temperature Control System, Digital Position Control System, Stepping Motors and Their Control, Programmable Logic Controllers	**12**	**24**
5.	**Design of Digital Control Algorithms:**	**8**	**14**

	z-Plane Specifications of Control System Design, Digital Compensator Design using Frequency Response Plots, Digital Compensator Design using Root Locus Plots, z-Plane Synthesis		
6.	**Control System Analysis using State Variable Methods** Introduction to State Variable Model, relation between transfer function and state space model for a discrete time system and various standard or canonical state variable models, Characteristic Equation, Eigenvalues and Eigen vectors, Controllabilit and Observability, Stability of discrete state space models, Multivariable Systems.	**10**	**20**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
14	**28**	**28**	**-**	**-**	**-**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. M. Gopal, "Digital Control and State Variable Methods 4/E", McGraw Hill Education
2. Hemchandra Madhusudan Shertukde, "Digital Control Applications Illustrated with MATLAB" 2015, CRC Press
3. B. C. Kuo, "Digital Control Systems 2/E", Oxford University Press-New Delhi
4. Landau Landau, Zito Landau, "Digital Control Systems : Design, Identification and Implementation, 1/E", Springer-Verlag
5. V. I. George, C.P. Kurian, " Digital Control Systems 1/E", Cengage Learning
6. Kavita Singh, Rashmi Vashisth, "Digital Control System", Galgotia Publications

Course Outcome: After learning the course the students will be able to:

1. Students will be able to develop mathematical models for controlling system behaviour.
2. Students will be able to digital control the systems with nonlinear behavious.
3. Students will learn fundamentals and applications of digital control for multidisciplinary engineering problems.
4. Students will learn fundamentals of intelligent/smart control systems used for industrial automation.

List of Experiments:

1. Describes the process of digital control, followed by a review of Z-transforms, feedback control concepts, and s-to-z plane conversions, mappings, signal sampling, and data reconstruction
2. Presents mathematical representations of discrete systems affected by the use of advances in computing methodologies and the advent of computers
3. Demonstrates state-space representations and the construction of transfer functions and their corresponding discrete equivalents

4. Explores steady-state and transient response analysis using Root-Locus, as well as frequency response plots and digital controller design using Bode Plots
5. Explains the design approach, related design processes, and how to evaluate performance criteria through simulations and the review of classical designs
6. Studies advances in the design of compensators using the discrete equivalent and elucidates stability tests using transformations
7. Employs test cases, real-life examples, and drill problems to provide students with hands-on experience suitable for entry-level jobs in the industry

Design based Problems (DP)/Open Ended Problem:

Students may carry out analysis of specific application based intelligent control system with its mathematical analysis and feedback control system. Control system analysis may be of a linear, nonlinear or discrete category and can be carried out using any simulation software.

Major Equipments:

1. All these experimental study with Software Tool: MATLAB.
2. MATLAB contains Control Systems Toolbox, Digital Signal Processing Toolbox, Fuzzy Toolbox, Neural Toolbox.
3. Control Experiment Equipment: PID Control, Discrete-time Control Systems, PLC & PLC Simulator.

List of Open Source Software/learning website:

1. Learning Resource by NPTEL, http://nptel.ac.in/courses/108103008/, Contributors: Indrani Kar, Somanath Majhi, Dept. of Electronics and Electrical Engg., IIT, Guwahati
2. Web Supplements provided by Gopal, M.: http://www.mhhe.com/gopal/dc4e

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.