GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3142407

Semester – IV (Power Electronics)
Subject Name: Control Theory

Type of course: Professional Core Course.

Prerequisite: Mathematics, Physics, Circuit Theory

Rationale: Automatic control of industrial processes is essential for increasing the output and in turn the profit of an industry. As a result, most of the companies are using automatic control of the machineries and processes. As an engineer, a student must know the basics of automatic control system. This subject is intended to supplement the basic skill of an engineer.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Contents:

Sr. No.	Content	Total Hrs	% Weightage
1	**Introduction to Control Systems:** Introduction, Historical development, terminology of control system, examples of Control Systems, Closed-Loop Control Versus Open-Loop Control, concept of design and compensation of Control Systems	4	10
2	**Mathematical Modeling of Control Systems:** Transfer Function and Impulse- Response Function, Automatic Control Systems, Modeling in State Space, State-Space Representation of Scalar Differential Equation Systems, Transformation of Mathematical Models, Linearization of Nonlinear Mathematical Models, Mathematical Modeling of Mechanical Systems, Mathematical Modeling of Electrical Systems	8	15
3	**Transient and Steady-State Response Analyses:** Type and Order of systems, First-Order Systems, Second-Order Systems, Higher-Order Systems, Transient-Response Analysis, Routh's Stability Criterion, Concept of Integral and derivative controls and their Effects on System Performance, Steady-State Errors in Unity-Feedback Control Systems	**8**	15
4	**Root-Locus Method of Control System Analysis and design:** Introduction, Root-Locus Plots, Root-Locus Plots of Positive Feedback Systems, Root-Locus Approach to Control-Systems Design, Lead Compensation, Lag Compensation, Lag–Lead Compensation, Parallel Compensation	**8**	20

5	**Frequency-Response Methods of Control System Analysis and Design:** Introduction, Bode Diagrams, Polar Plots, Log-Magnitude-versus-Phase Plots, Nyquist Stability Criterion, Stability Analysis, Relative Stability Analysis, Closed-Loop Frequency Response of Unity-Feedback Systems, Experimental Determination of Transfer Functions, Control Systems Design by Frequency-Response Approach, Lead Compensation, Lag Compensation, Lag–Lead Compensation	8	20
6	**Controllers and Tuning:** Introduction and classification, Ziegler–Nichols Rules for Tuning PID Controllers, Design of PID Controllers with Frequency-Response Approach, Design of PID Controllers with Computational Optimization Approach, Modifications of PID Control Schemes, Two-Degrees-of-Freedom Control, Zero-Placement Approach to Improve Response Characteristics	8	20

Suggested Specification table with Marks (Theory):

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	**30**	**20**	**20**	**10**	**-**

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, "Control Systems: Principles and Design", McGraw Hill Education.
2) B. C. Kuo, "Automatic Control System", Prentice Hall
3) K. Ogata, "Modern Control Engineering", Prentice Hall, 1991.
4) J. Nagrath and M. Gopal, "Control Systems Engineering", New Age International, 2009.
5) A. Anand kumar, "Control Systems" PHI Pvt. Ltd, 2014.

Course Outcomes:

After studying this course, students should be able to

Sr. No.	**CO statement**	**Marks % weightage**	**Topics Mapped**
CO-1	categorize different types of control system and identify a set of algebraic equations to represent and model a real system into simple form.	15	CO-1
CO-2	characterize any system in Laplace domain to illustrate different specification of the system using transfer function concept.	15	CO-1, CO-2,
CO-3	interpret different physical and mechanical systems in terms of electrical system to construct equivalent electrical models for analysis.	20	CO-4

CO-4	employ time domain analysis to predict and diagnose transient performance parameters of the system for standard input functions.	20	CO-6
CO-5	formulate different types of analysis in frequency domain to explain the nature of stability of the system.	20	CO-5, CO-6
CO-6	identify the needs of different types of controllers and compensator to ascertain the required dynamic response from the system.	10	CO-6

Suggested List of Experiments:

All experiments are based on simulation software like OCATVE, SCILAB, MATLAB etc.

1. Study of transfer function
2. Study time response analysis
3. Study of model simplification
4. Study of pole-zero location and stability
5. Study of Root Locus
6. Study of Bode Plot
7. Study of Nyquist Plot

List of Open Source Software/learning website:

- OCTAVE - https://www.gnu.org/software/octave/
- SCILAB - www.scilab.org
- Swayam- https://swayam.gov.in/
- NPTEL- https://onlinecourses.nptel.ac.in/
- Mooc- http://mooc.org/
- Edx - https://www.edx.org/
- Coursera- https://www.coursera.org/
- Udacity - https://in.udacity.com/
  Udemy - https://www.udemy.com/
- Khanacademy - https://www.khanacademy.org/
- Skillshare - https://www.skillshare.com/
- Harvard University - https://online-learning.harvard.edu/
- Ted - https://ed.ted.com/
- Alison - https://alison.com/
- Futurelearn - https://www.futurelearn.com/
- Open Learn - http://www.open.edu/openlearn/
- Future Learn - https://www.futurelearn.com/
- Tuts Plus - https://tutsplus.com/
- Open Culture - http://www.openculture.com/