DISCIPLINE SPECIFIC CORE COURSE – 18: Control Systems (INDSC6C)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Control Systems (INDSC6C)	04	03	-	01	Class XII passed with Physics + Mathematics/Applied Mathematics + Chemistry/ Computer Science/Informatics Practices	Engineering Mathematics

Learning Objectives

The Learning Objectives of this course are as follows:

- To study how to interpret and apply block diagram representations of control systems and design PID controllers based on empirical tuning rules
- To help the students understand and practice feedback and feed-forward control architecture and discuss the importance of performance, robustness and stability in control system design
- To teach about how to solve the steady state and transient analysis of a system for standard inputs
- Introduce students how to compute stability of linear systems using the Routh array test and use this to generate control design constraints
- To teach students the use Evans root locus techniques in control design for real world systems

Learning outcomes

The Learning Outcomes of this course are as follows:

- Interpret and apply block diagram representations of control systems and design PID controllers based on empirical tuning rules
- Define and explain feedback and feed-forward control architecture and discuss the importance of performance, robustness and stability in control system design
- Solve the steady state and transient analysis of a system for standard inputs

- Compute stability of linear systems using the Routh array test and use this to generate control design constraints
- Use Evans root locus techniques in control design for real world systems
- Compute gain and phase margins from Bode diagrams and Nyquist plots and understand their implications in terms of robust stability

SYLLABUS OF DSC-18

UNIT – 1 **(11 hours)**

Introduction to Control System: Introduction of open loop and closed loop control systems, mathematical modelling of physical systems (Electrical, Mechanical), derivation of transfer function, Armature controlled and field controlled DC servomotors, block diagram representation & signal flow graph, reduction technique, Mason's Gain Formula, effect of feedback on control systems.

UNIT – 2 **(11 hours)**

Time Domain Analysis: Time domain performance criteria, transient response of first, second, steady state errors and static error constants, performance indices.

Concept of Stability: Asymptotic stability and conditional stability, Routh – Hurwitz criterion, relative stability analysis, Root Locus plots and their applications.

UNIT – 3 **(12 hours)**

Frequency Domain Analysis: Frequency Domain Analysis: Correlation between time and frequency response, Polar plots, frequency domain specifications, Logarithmic plots (Bode Plots), gain and phase margins, Nyquist stability criterion, relative stability using Nyquist criterion.

UNIT – 4 **(11 hours)**

State Space Analysis: Definitions of state, state variables, state space, representation of systems, Solution of time invariant, homogeneous state equation, state transition matrix and its properties.

Controllers and Compensation Techniques: Basic Control Actions: Proportional, Integral and Derivative controls, response with P, PI and PID Controllers, Basic concept of compensation, Lag, Lead and Lag-Lead networks.

Practical component: **(30 hours)**

1. To study characteristics of :
   a. Synchro transmitter receiver
   b) Synchro as an error detector
1. To study position control of DC motor
2. To study speed control of DC motor
3. To find characteristics of AC servo motor
4. To study time response of type 0,1 and 2 systems
5. To study frequency response of first and second order systems

6. To study time response characteristics of a second order system.
7. To study effect of damping factor on performance of second order system
8. To study frequency response of Lead and Lag networks.
9. Study of P, PI and PID controller.

Essential/recommended readings

1. J. Nagrath& M. Gopal, Control System Engineering, New Age International, 2021, 7th Edition.
2. K. Ogata, Modern Control Engineering, Prentice Hall of India, 2015, 5th Edition.
3. B. C. Kuo , "Automatic control system", Prentice Hall of India, 2010, 9th Edition.
4. B. S. Manke, Linear Control Systems, Khanna Publishers, Delhi, 7th Edition.

Suggestive readings

1. N.K Jain, Automatic Control System Engineering, DhanpatRai Publication, 2019, Standard Edition.
2. Veenadevi S V and Sujatha Hiremath, Control System, I K International Publishing House Pvt Ltd, 2022.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.