16EE301 CONTROL SYSTEMS

Hours Per Week :

L	T	P	C
3	-	2	4

Total Hours :

L	T	P
45	-	30

WA/RA	SSH/HSH	CS	SA	S	BS
15	30	-	5	5	-

Course Description and Objectives:

This course offers the basic concepts of modeling, analysis and design of control systems, restricted to linear continuous time systems. The objective of the course is to introduce the modeling of systems from physical laws, feedback characteristics and a few important control system components. In addition, it also provides graphical methods to analyze and assess system stability in time and frequency domains. Further, it introduces the state variable approach and basics of controllers design.

Course Outcomes:

The student will be able to:

- formulate mathematical models of physical systems and represent them in block diagrams and signal flow graphs.
- analyze transient and steady state performance of a system.
- understand the stability of an electrical, electronics and other physical systems.
- design controllers and compensators.

SKILLS:

- ***ü*** *Model any physical system (Electrical, Mechanical, Electro-mechanical…).*
- ***ü*** *Determine overall transfer function of a system using Block Diagram Reduction Technique and SFG method.*
- ***ü*** *Analyse first and second order systems in time domain.*
- ***ü*** *Determine design specifications like rise time, settling time , steady state error..*
- ***ü*** *Analyse system stability using R-H Criterion.*
- ***ü*** *Determine open loop gain variation in a stable system using Root Locus Method.*
- ***ü*** *Carry out stability analysis of any system in the Frequency domain.*
- ***ü*** *Design Lag, Lead Compensator using R, L and C for any Linear Time Invariant System.*

ACTIVITIES:

- *Realization of Lag, Lead Compensator using R,L and C for any specification*
- *Design of a speed controller for an AC Servo motor*
- *Design of speed controlled DC motor for domestic applications*
- *Op-amp based PID controller design for a DC motor*
- *Design a position controller for a motor used in domestic applications*
- *Design a temperature controller for a home heating system*

UNIT - 1 **L-10**

INTRODUCTION TO CONTROL SYSTEMS:

Introduction: Concepts of control systems - Open loop and closed loop control systems and their differences; Different examples of control systems, Classification of control systems.

Mathematical Models of Physical Systems: Differential equations, Transfer function and block diagram representation of electrical systems; Block diagram algebra, Signal flow graph reduction using Mason's gain formula, Translational and rotational mechanical systems.

UNIT - 2 **L-8**

FEED-BACK CHARACTERISTICS AND CONTROL COMPONENTS:

Feed-Back Characteristics: Effects of feedback - Reduction of parameter variations, Control over system dynamics.

Elements of Control Systems: Operation and derivation of transfer function of DC and AC Servo motors, Synchro transmitter and receiver.

UNIT - 3 **L-9**

TIME RESPONSE ANALYSIS AND STABILITY:

Time Response Analysis: Standard test signals, Time response of first order systems, Characteristic equation and transient response of second order systems, Time domain specifications, Steady state response, Steady state errors and error constants.

Stability: Concept of stability, Routh stability criterion.

UNIT - 4 **L- 10**

RL TECHNIQUE AND FREQUENCY RESPONSE ANALYSIS:

Root Locus Technique: Root locus concept - Construction of root loci and analysis.

Frequency Response Analysis: Introduction, Frequency domain specifications, Bode plots - Construction and determination of frequency domain specifications, Phase margin, Gain margin and stability analysis; Introduction to polar plots, Nyquist plots and Nyquist stability criterion.

UNIT - 5 **L-8**

COMPENSATION TECHNIQUES AND STATE SPACE ANALYSIS:

Compensation Techniques: Design problem, Preliminary design considerations, Realization of basic compensators - Lead, Lag and Lead-lag; PID controllers.

State Space Analysis : Concept of state variables and state model, Derivation of state models from block diagrams and diagonalization, Solving the time Invariant state equations, State transition matrix.

LABORATORY EXPERIMENTS

LIST OF EXPERIMENTS Total hours: 30

1. Time response of Second order system.
2. Characteristics of Synchros.
3. Study of Temperature Control System.
4. Transfer function of DC generator.
5. Characteristics of magnetic amplifier.
6. Characteristics of AC servo motor.
7. Linear system analysis (Time domain and Error analysis) using MATLAB.
8. Design of PID controller using MATLAB.
9. Stability analysis of Linear Time Invariant system using MATLAB.
10. State space model for classical transfer function using MATLAB – Verification.

TEXT BOOKS :

1. I. J. Nagrath and M. Gopal, “Control Systems Engineering”, 2nd edition, New Age International (P) Limited, 2010.
2. Katsuhiko Ogata, “ Modern Control Engineering “ 5th edition, Prentice Hall of India Private Ltd., New Delhi, 2010.

REFERENCE BOOKS :

1. Norman S. Nise, “Control Systems Engineering”, 3rd edition, John wiley and son’s, 2000.
2. M. Gopal, “ Control Systems: Principles and Design “, 3rd edition, McGraw,Hill, 2008
3. Benjamin C Kuo, “ Automatic Control system”, Prentice Hall of India PrivateLtd., New Delhi, 2009.
4. R.C. Dorf and R.H. Bishop, “ Modern Control Systems”, 12th edition, Prentice, Hall, 2010.