CONTROL SYSTEMS

Course Code: 22EE1104

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Prerequisites: Physics, Ordinary Differential Equation and Vector Calculus, Ordinary Differential Equation and Vector Calculus

Course Outcomes: At the end of the Course the student shall be able to
CO1: Evaluate the performance and benefits of basic open loop and closed loop systems.
CO2: Determine transfer function from block diagram using reduction techniques
CO3: Determine the time response and stability of linear time invariant systems
CO4: Test the stability of systems using Bode plot, Polar plot and Nyquist criterion
CO5: Assess the state space model and test the controllability and observability

UNIT-I **8 Lectures**
INTRODUCTION:

System representation – Classification of systems – Open loop control - Feedback control – Benefits of feedback – Open – loop and closed-loop systems – Industrial control examples.

Learning Outcomes: Students should be able to

1. explain the classification of systems (L2)
2. compare the benefits of closed loop and open loop systems (L5)
3. illustrate the industrial control examples (L3)

UNIT-II **10 Lectures**
MODELLING OF CONTROL SYSTEMS:

Mathematical models of Physical systems-Transfer function models of linear time-invariant systems-Electrical, Mechanical and Electro-Mechanical Systems-Electrical Analogues- Block diagram and their Reduction techniques, Signal flow graphs, AC and DC servo motors, Potentiometer pair, Synchros.

Learning Outcomes: Students should be able to

1. model analogous systems (Electrical to mechanical and vice versa) (L3)
2. determine the transfer function using block diagram reduction techniques (L3)
3. apply signal flow graph technique to obtain the transfer function (L3)

UNIT-III **10 Lectures**
STABILITY ANALYSIS

Concept of stability – Absolute stability and relative stability – Routh - Hurwitz criterion.

TIME - DOMAIN ANALYSIS

Standard test signals. Time responses of first order and second order systems for standard test inputs. Design specifications for second-order systems-Steady state error -Static and generalized error constants.

ROOT LOCUS TECHNIQUE

Construction of root-loci.

Learning Outcomes: Students should be able to

1. determine time response of first and second order systems (L3)
2. determine steady state and generalized error coefficients (L3)
3. determine the stability of the system using RH criterion and Root locus technique (L3)

UNIT-IV — 12 Lectures

FREQUENCY- DOMAIN ANALYSIS

Introduction to frequency domain specifications -Relationship between time and frequency responses, Polar plots, Bode plots, Stability analysis using gain margin and phase margin. Nyquist stability criterion, Relative stability using Nyquist criterion.

COMPENSATION TECHNIQUES:

Types of compensators, and design of Lag, Lead and Lag-Lead compensators using Bode plots, P, PI, PD and PID controllers.

Learning Outcomes: Students should be able to

1. determine the stability of the system using Bode plots (L3)
2. assess the relative stability of the system using Nyquist criterion (L5)
3. design Compensators (L3)

UNIT-V — 10 Lectures

STATE VARIABLE ANALYSIS

Concept of state variables- State space model- Diagonalization of a matrix- Solution of state equations- Eigenvalues and stability analysis-State Transition Matrix-Concepts of controllability and observability.

Learning Outcomes: Students should be able to

1. determine the state space model and deduce its solution (L3)
2. determine the state transition matrix, obtain the Eigenvalues and assess the stability (L3)
3. Test the system for controllability and Observability (L5)

TEXT BOOK:

1. I. J. Nagrath and M. Gopal, *Control Systems Engineering*, New Age International, 6th Edition 2018

REFERENCES:

1. M. Gopal, *Control Systems: Principles and Design*, McGraw Hill Education,4th Edition 2012.
2. F.Golnaraghi and B.C.Kuo, Automatic Control Systems, 9th Edition, Wiley, 2014.
3. K. Ogata, *Modern Control Engineering*, 5th Edition, Prentice Hall, 2009.