Course Name: Control System I

Course Code : EE503

Course Credit: 4

Contact Hour: 3T-1T

Prerequisite: Basic Electrical Engineering, Circuit Theory, Laplace transform, second order differential Equation.

Course Objective

The course objectives are:

1. To provide with basic knowledge of control systems, associated terminologies, transfer function.
2. Familiar with basic electrical, mechanical & electromechanical system and their representation in Differential Equation /Transfer function form.
3. To understand different methods to simplify large system and represent in a single transfer function block.
4. To make students familiar with system performance analysis in time & frequency domain.
5. To provide basic pathway to design controllers & compensators for a particular system to meet desired response.

Course Outcome

On completion of the course students will be able to

1. Understand the basic concepts of control systems, pole, zero and can analyze system stability on that basis.
2. Develop electrical models/ mechanical models to design a physical system for a specific operation.
3. Understand and implement mathematical tools (such as SFG) to analyze a complete system.
4. Understand, define different time domain specification parameters and thus can apply that knowledge to conclude dynamic performance of a system.
5. Analyze system's absolute, relative, local stability using different frequency domain methods.
6. Understand, explain, and design analog controllers, compensators and their selection to meet desired response.

CO Mapping with departmental POs

H: High, M: Medium, L: Low

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	H	H	M	H	M							
CO 2	H	M	H	H	M							
CO 3	M	M	M	H	M							
CO 4	H	H	M	H	H							
CO 5	H	H	M	H	M							
CO 6	H	H	H	H	M							

Course Content:

Module I: Introduction to control system **2L**

Concept of feedback and Automatic control, Effects of feedback, Objectives of control system, Definition of linear and nonlinear systems, Elementary concepts of sensitivity and robustness. Types of control systems, Servomechanisms and regulators, examples of feedback control systems. Transfer function concept. Pole and Zeroes of a transfer function. Properties of Transfer function.

Module II: Mathematical modeling **9L**

Mathematical modeling of dynamic systems: Translational systems, Rotational systems, Electrical system, Electro-mechanical system, Mechanical coupling, Liquid level systems, Electrical analogy of Spring–Mass-Dashpot system. Force –Voltage and Force – Current Analogy, Amplitude scaling and Time Scaling.

Block diagram representation of control systems. Block diagram algebra. Signal flow graph. Mason's gain formula.

Module III: Control system components **3L**

Potentiometer, Synchros, Resolvers, Position encoders. DC and AC tacho-generators. Actuators. Block diagram level description of feedback control systems for position control, speed control of DC motors, temperature control, liquid level control, voltage control of an Alternator.

Module IV: Time domain analysis **10L**

Time domain analysis of a standard second order closed loop system. Concept of undamped natural frequency, damping, overshoot, rise time and settling time. Dependence of time domain performance parameters on natural frequency and damping ratio. Step and Impulse response of first and second order systems. Effects of Pole and Zeros on transient response. Stability analysis using Routh – Hurwitz Criterion.

Error Analysis: Steady state errors in control systems due to step, ramp and parabolic inputs. Concepts of system types and error constants.

Module V: Stability Analysis **15L**

Root locus techniques, construction of Root Loci for simple systems. Effects of gain on the movement of Pole and Zeros. Frequency domain analysis of linear system: Bode plots, Polar plots, Nyquist criteria, measure of relative stability, phase and gain margin. Determination of margins in Bode plot.

Module VI: Basic Control actions **2L**

Proportional, integral, derivative, and their combinations.

Module VII: Compensation of control systems in frequency domain **3L**

Lag compensator, lead compensator, lead-lag compensator.

Text Book:

1. I.J.Nagrath and M.Gopal, Control Systems Engineering, 5th edition, New Age International, 2009.
2. Linear Control Systems, Ashfaq Hussain, Haroon Ashfaq, Dhanpat Rai & co.
3. Control System Engineering, D. Roy Choudhury, PHI.

Reference Books:

1. Norman S. Nise, Control Systems Engineering, 6th edition, Wiley, 2011.
2. Benjamin C. Kuo and Farid Golnaraghi, Automatic Control Systems, 9th edition, Wiley; 2009.
3. M. Gopal, Control Systems Principles and Design, 3rd edition, Tata Mgraw Hill, 2008.
4. Richard C. Dorf and Robert H. Bishop, Modern Control Systems, 12th Edition, Prentice Hall, 2011.
5. Sushil Das Gupta, Control system theory, Khanna Publishers, 1987.