Short Syllabus

BECE302L Control Systems (2-1-0-3)

Control Systems - Basic components of a control system; Mathematical Modeling of Physical Systems - Difference and differential equations for LTI SISO and MIMO systems; Time Domain Response - Time domain specifications, Steady state error; Characterization of Systems – Stability, Root locus analysis; Frequency Domain Response - Phase and gain margin, Bode Plot; Controllers and Compensators Design - P, PI, PID controllers; State Space Analysis - Solutions of state equations of LTI system.

Course Code	Course Title	L	T	P	C
BECE302L	Control Systems	2	1	0	3
Pre-requisite	BECE202L	Syllabus version			
		1.0			

Course Objectives

1. To study the use of transfer function model for the analysis of physical systems and to introduce the components of control system.
2. To provide adequate knowledge in the time response of systems and steady state error analysis along with the understanding of closed-loop and open-loop system analysis in frequency domain.
3. To introduce the design of controllers and compensators for the stability analysis.
4. To introduce state variable representation of physical systems and study the stability analysis in state space approach.

Course Outcomes

Students will be able to

1. Differentiate between open-loop and closed-loop control systems and obtain the transfer function from the mathematical modeling of physical systems.
2. Determine transient and steady state responses of the system with first and second order and also to analyze its error coefficients.
3. Characterize the system stability using R-H criteria and root locus techniques.
4. Analyze the frequency domain response of the control systems.
5. Design the controllers and compensators to estimate the system stability.
6. Analyze the system in state space model through the concept of controllability and observability.

Module:1	Control Systems	3 hours

Basic components of a control system, Applications, Open-loop control system and closed-loop control system, Examples of control system (air conditioner, cruise control, phase-locked loop, etc.), Effects of feedback on overall gain, Types of feedback control system, Linear and non-linear control systems.

Module:2	Mathematical Modeling of Physical Systems	8 hours

Difference and differential equations for LTI SISO and MIMO systems, Mathematical modeling of electrical and mechanical systems, Equivalence between the elements of different types of systems, Transfer function of linear systems, Open-loop transfer function and closed-loop transfer function, Block diagram representation, Block diagram reduction techniques, Signal flow graph using Mason's gain formula.

Module:3	Time Domain Response	6 hours

Transient response and steady state responses, Time domain specifications, Types of test inputs, Response of first order and second order systems, Steady state error, Static error coefficients, Generalized error coefficients.

Module:4	Characterization of Systems	5 hours

Stability – concept and definition, Poles, Zeros, Order and Type of systems; R-H criteria, Root locus analysis.

Module:5	Frequency Domain Response	7 hours

Frequency response – Performance specifications in the frequency domain, Phase margin and gain margin, Bode plot, Polar plot and Nyquist plot, Stability analysis in frequency domain.

Module:6	Controllers and Compensators Design	7 hours

Controllers – P, PI, PID, Realization of basic compensators, Cascade compensation in time domain and frequency domain, Feedback compensation, Design of lag, lead, lag-lead series compensators.		
Module:7	**State Space Analysis**	**7 hours**
Dynamic system modeling in state space representation: Diagonal canonical form, Jordan canonical form, Solutions of state equations of LTI system, Conversion from state space model to transfer function model and vice versa, Stability analysis in state spaces: Concept of eigenvalues and eigenvectors, State transition matrix using Cayley-Hamilton theorem, Controllability and observability.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Norman S. Nise, Control Systems Engineering, 2019, 8th Edition, John Wiley & Sons, New Jersey, USA
Reference Books	
1.	Farid Golnaraghi and Benjamin C. Kuo, Automatic Control Systems, 2017, 10th Edition, McGraw-Hill Education, India.
2.	I.J. Nagarth and M. Gopal, Control Systems Engineering, 2018, 6th Edition, New Age International Pvt. Ltd., New Delhi, India.
3.	Gene Franklin, J. Powell and Abbas Emami-Naeini, Feedback Control of Dynamic Systems, 2019, 8th Edition, Pearson Education, New Delhi, India.

Mode of Evaluation: Continuous Assessment Test, Digital Assignment, Quiz and Final Assessment Test			
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