Savitribai Phule Pune University

Board of Studies - Mechanical and Automobile Engineering

Undergraduate Program – Final Year Automation and Robotics (2019 pattern)

402541: Industrial Automation & Control Systems

Teaching Scheme		Credits		Examination Scheme	
Theory	03 Hr./Week	**Theory**	3	**In-Semester**	30 Marks
Practical	02 Hr./Week	**Practical**	1	**End-Semester**	70 Marks
				Oral	25 Marks

Prerequisites: Mathematics course in differential equations, Laplace transforms, basic electrical network analysis.

Course Objectives:

1. Select & Apply appropriate power system for Automation systems
2. Understand Design of Fluid Power System
3. UNDERSTAND the Transient and steady-state responses and Stability.
4. UNDERSTAND to Compute the frequency domain specifications of a system.
5. UNDERSTAND the State space analysis of systems.
6. UTILIZE the various methods used for analyzing nonlinear systems.

Course Outcomes: On completion of the course the learner will be able to:

CO1. SELECT control systems in robots.
CO2. DESIGN Hydraulic Control System
CO3. DESIGN Pneumatic Control System
CO4. ANALYZE linear control system
CO5. ANALYZE non-linear control system
CO6. UNDERSTAND and USE appropriate control systems

Course Contents

Unit 1	**Automation & Fluid Power System**

Automation: Definition, Types, reasons for automating; Automation strategies, Introduction of fluid power system: significance in industrial automation, fluids & their properties, governing laws, symbols, working principle, design and analysis of reservoir, pumps, filters, valves, actuators, accumulators, intensifiers, special pneumatic components viz. logical valves, time delay valve, etc.

Unit 2	**Hydraulic Control Systems**

Standards in circuit diagram, Design considerations and component selection**.** Control of Single and Double -Acting Hydraulic Cylinder, Regenerative circuit, Pump Unloading Circuit, Counter balance Valve Detail analysis speed control, flow control, pressure control circuits, Safety circuit, Accumulators, types, construction and applications with circuits, Intensifier circuits. Proportional valves and servo valves in hydraulic circuit design.

PLC based electro-hydraulic systems, PLC programming using ladder logic for automation and robotics applications

Unit 3	**Pneumatic Control Systems**

Pneumatic circuits design using Displacement – Time and Travel-Step diagrams, sequencing and cascade circuits, Construction of pneumatic circuit diagrams for industrial applications. Use of Logic gates - OR and AND gates in pneumatic applications.

Electro-Pneumatic Control: Principles - signal input and output, pilot assisted solenoid control of directional control valves, Use of relay and contactors.

Unit 4	**Linear Systems**

Definition, Open loop vs closed-loop control systems- components of a typical control system- Necessity of a control system in a robot, bird's eye view of typical actuators in robot control systems-hydraulic, pneumatic and electric actuators

Transfer function, Necessity of knowing the transfer function, Modelling -Mechanical and Electromechanical systems – block diagram representation - block diagram reduction, characteristic equation, signal flow graph, overview Mason's gain formula; the Basic idea of feedbacks in robotic systems-sensors- eg. Linear and rotary encoders.

Unit 5	**Non-linear Systems**

Introduction - characteristics of nonlinear systems. Types of nonlinearities. Determination of describing the function of nonlinearities (relay, dead zone, and saturation only) - application of describing function for stability analysis of autonomous Robotics & Automation system with single nonlinearity. Singular points – Classification of singular points. Definition of stability-asymptotic stability and instability.

Unit 6	**Advance Automated Systems**

Introduction to Advance Automated Systems, definition and scope of automated systems, benefits and challenges, Large scale control systems: Distributed control system and Supervisory control and data Acquisition (SCADA), HMI, Remote Terminal Unit (RTU), Digital Communication Unit (DCU), Industrial automation using robots

Books and other resources

Text Books:

1. Antanio Espisito, Fluid Power with Applications, Pearson Education Seventh Edition
2. Process Control Instrumentation Technology Curtis D. Johnson Eighth Edition
3. I. J. Nagrath and M. Gopal, "Control Systems Engineering", New Age International Pvt Ltd, 6/e.
4. Katsuhiko Ogata, "Modern Control Engineering", Pearson Education India, 5/e.
5. M. Gopal, "Control Systems Principles and Design", McGraw Hill Education (India) Pvt. Ltd., 4/e.
6. A. Anand Kumar, "Control Systems", PHI, 2/e.
7. D. Roy Choudhury, "Modern Control Engineering", PHI.
8. Peter Corke, Robotics, Vision and Control: Fundamental Algorithms in MATLAB, Springer.

References Books:

1. Nise N. S., Control Systems Engineering, 6/e, Wiley Eastern, 2010.
2. Dorf R. C. and R. H. Bishop, Modern Control Systems, Pearson Education, 2011.
3. Hassan K Khalil, Nonlinear Systems, Prentice - Hall International (UK), 2002.
4. Ashitava Ghosal, Robotics- Fundamental Concepts and Analysis, Oxford University Press.
5. Control System Engineering, Gupta, Wiley Publications.
6. Control Engineering, K. P. Ramachandran, Wiley Publications.

Web References:

1. NPTEL Course "Control System" - https://nptel.ac.in/courses/107/106/107106081/
2. NPTEL Course "Control System Design" - https://nptel.ac.in/courses/115/108/115108104/
3. NPTEL Course "Advanced Linear Continuous Control Systems: Applications with MATLAB Programming and Simulink" - https://nptel.ac.in/courses/108107115/

Guidelines for Laboratory Sessions

1. Assessment must be based on an understanding of theory, attentiveness during practice, and understanding.
2. There should be continuous assessment and Timely submission of the journal.
3. Use suitable software wherever necessary to perform experiments.

The student shall perform any 8 experiments of the following:

1. Case study - Design of speed control hydraulic circuits.
2. Case study - Design of regenerative circuits
3. Case study - Design of electro-hydraulic sequencing circuits
4. Experiment on pneumatic circuits by demonstrating logic gates.
5. Experiment on electro-pneumatic circuits
6. Experiment on programmable logic controllers: Ladder logic programming
7. Microprocessor programming for basic operations.
8. Microcontroller programming for basic operations.
9. Computation of transfer function of Electric Circuits, Mechanical Circuits for concept understanding with their analogy Force-Voltage and Force Current.
10. Stability analysis for any given system with Characteristic Equation given (Software Simulation).
11. Observe the effect of P, PI, PD, and PID controllers on the step response of a feedback control system. Comment on the effect of Controller mode Time domain specifications/ analysis.