# INSTITUTE OF AERONAUTICAL ENGINEERING

**(Autonomous)**

Dundigal, Hyderabad -500 043

## ELECTRICAL AND ELECTRONICS ENGINEERING

## COURSE DESCRIPTOR

| | | | | | |
|---|---|---|---|---|---|
| **Course Title** | **CONTROL SYSTEMS LABORATORY** | | | | |
| **Course Code** | AEEB18 | | | | |
| **Programme** | B.Tech | | | | |
| **Semester** | IV | EEE | | | |
| **Course Type** | Core | | | | |
| **Regulation** | IARE - R18 | | | | |
| **Course Structure** | **Theory** | | | **Practical** | |
| | **Lectures** | **Tutorials** | **Credits** | **Laboratory** | **Credits** |
| | - | - | - | 2 | 1 |
| **Chief Coordinator** | K.Harshini, Assistant Professor | | | | |
| **Course Faculty** | K.Harshini, Assistant Professor | | | | |

## I. COURSE OVERVIEW:

This course is aimed to introduce the students the principles and applications of control systems in everyday life. The basic concepts of block diagram reduction, time response analysis solutions to time invariant systems and it also deals with the different aspects of stability analysis of systems in frequency domain and time domain. Introduction and Implementation of PLC'S for practical applications in control systems.

## II. COURSE PRE-REQUISITES:

| Level | Course Code | Semester | Prerequisites | Credits |
|---|---|---|---|---|
| UG | AHS011 | II | Mathematical Transform techniques | 4 |

## III. MARKS DISTRIBUTION:

| Subject | SEE Examination | CIA Examination | Total Marks |
|---|---|---|---|
| Control System And Simulation Laboratory | 70 Marks | 30 Marks | 100 |

## IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ✔ | Chalk & Talk | ✘ | Quiz | ✘ | Assignments | ✘ | MOOCs |
| ✔ | LCD / PPT | ✘ | Seminars | ✘ | Mini Project | ✘ | Videos |
| ✔ | Open Ended Experiments | | | | | | |

## V. EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks for internal assessment and 70 marks for semester end lab examination. Out of 30 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance and 10 marks for the final internal lab assessment.

**Semester End Examination (SEE):** The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the lab courses is divided into fourteen weeks. From 1st to 7th week hardware and MATLAB based experiments and from 8th to 14thweek PLC based experiments will be carried out. Among the 14 experiments, one compulsory question without any choice will be given for SEE.

The emphasis on the experiments is broadly based on the following criteria:

| | |
|---|---|
| 20 % | To test the preparedness for the experiment. |
| 20 % | To test the performance in the laboratory. |
| 20 % | To test the calculations and graphs related to the concern experiment. |
| 20 % | To test the results and the error analysis of the experiment. |
| 20 % | To test the subject knowledge through viva – voce. |

**Continuous Internal Assessment (CIA):**
The CIE exam is conducted for 30 marks for internal evaluation (20 marks for day-to-day work, and 10 marks for internal tests). There shall be one internal test for 10 marks in the Semester.

Table 1: Assessment pattern for CIA

| **Component** | **Laboratory** | | **Total Marks** |
|---|---|---|---|
| **Type of Assessment** | Day to day performance | Final internal lab assessment | |
| **CIA Marks** | 20 | 10 | 30 |

**Continuous Internal Examination (CIE):**
Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively. The CIE exam is conducted for 10 marks of 3 hours duration. Marks are awarded by taking average of marks scored in two CIE exams.

| **Preparation** | **Performance** | **Calculations and Graph** | **Results and Error Analysis** | **Viva** | **Total** |
|---|---|---|---|---|---|
| 2 | 2 | 2 | 2 | 2 | 10 |

## VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

| Program Outcomes (POs) | | Strength | Proficiency assessed by |
|---|---|---|---|
| PO 1 | **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems. | 2 | Calculations of the observations |
| PO 2 | **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. | 2 | Calculations of the observations |
| PO 3 | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. | 3 | Characteristic curves |
| PO 4 | **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. | 2 | Laboratory Practices |
| PO 5 | **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations | 2 | Projects |

**3 = High; 2 = Medium; 1 = Low**

## VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

| Program Specific Outcomes (PSOs) | | Strength | Proficiency assessed by |
|---|---|---|---|
| PSO 1 | Able to utilize the knowledge of high voltage engineering in collaboration with power systems in innovative, dynamic and challenging environment, for the research based team work. | 2 | Projects |
| PSO 2 | Can explore the scientific theories, ideas, methodologies and the new cutting edge technologies in renewable energy engineering, and use this erudition in their professional development and gain sufficient competence to solve the current and future energy problems universally. | - | - |
| PSO 3 | The understanding of technologies like PLC, PMC, process controllers, transducers and HMI one can analyze, design electrical and electronics principles to install, test , maintain power system and applications. | 3 | Laboratory Practices |

**3 = High; 2 = Medium; 1 = Low**

## VIII. COURSE OBJECTIVES (COs):

| The course should enable the students to: | |
|---|---|
| I | Understand mathematical models of electrical and mechanical systems. |
| II | Analysis of control system stability using digital simulation. |
| III | Demonstrate the time domain and frequency domain analysis for linear time invariant systems. |
| IV | Apply programmable logic controllers to demonstrate industrial controls in the laboratory. |

## IX. COURSE LEARNING OUTCOMES (CLOs):

| CLO Code | CLO's | At the end of the course, the student will have the ability to: | PO's Mapped | Strength of Mapping |
|---|---|---|---|---|
| AEEB18.01 | CLO 1 | Demonstrate the response of first order and second order systems with various standard test signals. | PO1, PO2, PSO1 | 2 |
| AEEB18.02 | CLO 2 | Understand the concept of time domain analysis of series RLC Circuit. | PO1, PO2, PSO1 | 2 |
| AEEB18.03 | CLO 3 | Identify the transfer function and analyze the time response of DC motor. | PO1, PO2, PSO1 | 2 |
| AEEB18.04 | CLO 4 | Examine the speed torque characteristics of AC Servomotor. | PO2, PO3, PSO1 | 3 |
| AEEB18.05 | CLO 5 | Estimate the error obtained in control system with the effect of P, PI, PID controllers. | PO3, PO4, PSO1 | 2 |
| AEEB18.06 | CLO 6 | Design of lead, lag, lag-lead compensator to improve characteristics of control system. | PO3, PO4, PSO1 | 2 |
| AEEB18.07 | CLO 7 | Record the dynamic behavior of temperature control system with P, PI, PID controllers. | PO2, PO3, PSO1 | 2 |
| AEEB18.08 | CLO 8 | Construct the PID controller using Op-Amps and verify using MATLAB. | PO2, PO3, PSO3 | 2 |
| AEEB18.09 | CLO 9 | Analyze the stability of time invariant control system using root locus, bode plot, polar plot, nyquist criterions. | PO2, PO5, PSO1 | 2 |
| AEEB18.10 | CLO 10 | Calculate the transfer function from state space model and state space model from transfer function using MATLAB | PO2, PO5, PSO3 | 3 |
| AEEB18.11 | CLO 11 | Implement ladder diagrams, truth tables, counter, blinking of lights ,control of water level using PLC | PO2, PO3, PO5, PSO3 | 3 |
| AEEB18.12 | CLO 12 | Implement ladder diagrams for blinking of lights ,control of water level using PLC | PO2, PO3, PO5, PSO3 | 2 |

**3 = High; 2 = Medium; 1 = Low**

## X. MAPPING COURSE LEARNING OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

| Course Learning Outcomes (CLOs) | Program Outcomes (POs) | | | | | | | | | | | | Program Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
| CLO 1 | 2 | 2 | | | | | | | | | | | 2 | | |
| CLO 2 | 2 | 2 | | | | | | | | | | | 2 | | |
| CLO 3 | 2 | 2 | | | | | | | | | | | 2 | | |
| CLO 4 | | 2 | 3 | | | | | | | | | | 2 | | |
| CLO 5 | | | 3 | 2 | | | | | | | | | 2 | | |
| CLO 6 | | | 2 | 2 | | | | | | | | | 2 | | |
| CLO 7 | | 2 | 2 | | | | | | | | | | 2 | | |
| CLO 8 | | 2 | 3 | | | | | | | | | | | | 3 |
| CLO 9 | | 2 | | | 2 | | | | | | | | | | 3 |

| Course Learning Outcomes (CLOs) | Program Outcomes (POs) | | | | | | | | | | | | Program Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
| CLO 10 | | 2 | | | 2 | | | | | | | | | | 3 |
| CLO 11 | | 2 | 3 | | 2 | | | | | | | | | | 3 |
| CLO 12 | | 2 | 3 | | 2 | | | | | | | | | | 3 |

**3 = High; 2 = Medium; 1 = Low**

## XI. ASSESSMENT METHODOLOGIES – DIRECT

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| CIE Exams | PO 1, PO 2 PO 3, PO 4, PO 5 | SEE Exams | PO 1, PO 2 PO 3, PO 4, PO 5 | Assignments | - | Seminars | - |
| Laboratory Practices | PO 1, PO 2 PO 3, PO 4,PO 5 | Student Viva | PO 1, PO 2 PO 3,PO 4, PO 5 | Mini Project | - | Certification | - |

## XII. ASSESSMENT METHODOLOGIES - INDIRECT

| | | | |
|---|---|---|---|
| ✔ | Early Semester Feedback | ✔ | End Semester OBE Feedback |
| ✘ | Assessment of Mini Projects by Experts | | |

## XIII. SYLLABUS

| LIST OF EXERCISES | |
|---|---|
| **Week-1** | **TIME RESPONSE OF SECOND ORDER SYSTEM** |
| To obtain the time response of a given second order system with time domain specifications. | |
| **Week-2** | **TRANSFER FUNCTION OF DC MOTOR** |
| Determine the transfer function, time response of DC motor and verification with digital simulation. | |
| **Week-3** | **AC SERVO MOTOR** |
| Study of AC servomotor and plot its torque speed characteristics. | |
| **Week-4** | **EFFECT OF VARIOUS CONTROLLERS ON SECOND ORDER SYSTEM** |
| Study the effect of P, PD, PI and PID controller on closed loop second order systems**.** | |
| **Week-5** | **COMPENSATOR** |
| Study lead-lag compensator and obtain its magnitude, phase plots. | |
| **Week-6** | **TEMPERATURE CONTROLLER** |
| Study the performance of PID controller used to control the temperature of an oven. | |
| **Week-7** | **DESIGN AND VERIFICATION OF OP-AMP BASED PID CONTROLLER** |
| Implementation of op-amp based PID Controller and verification using MATLAB | |

| | |
|---|---|
| **Week-8** | **STABILITY ANALYSIS USING DIGITAL SIMULATION** |
| Stability analysis using root locus, Bode plot, Polar, Nyquist criterions of linear time invariant system by digital simulation. | |
| **Week-9** | **STATE SPACE MODEL USING DIGITAL SIMULATION** |
| Verification of state space model from transfer function and transfer function from state space model using digital simulation. | |
| **Week-10** | **LADDER DIAGRAMS USING PLC** |
| Input output connection, simple programming, ladder diagrams, uploading, running the program and debugging in programmable logic controller. | |
| **Week-11** | **TRUTH TABLES USING PLC** |
| Study and verification of truth tables of logic gates, simple boolean expressions and application to speed control of DC motor using programmable logic controller. | |
| **Week-12** | **IMPLEMENTATION OF COUNTER** |
| Implementation of counting number of objects and taking action using PLC. | |
| **Week-13** | **BLINKING LIGHTS USING PLC** |
| Implementation of blinking lights with programmable logic controller. | |
| **Week-14** | **WATER LEVEL CONTROL** |
| Control of maximum and minimum level of water in a tank using PLC. | |

**TEXT BOOKS:**

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|---|---|
| 1 | Norman S. Nise, "Control Systems Engineering", John Wiley & Sons, Inc., 6th Edition, 2004. |
| 2 | J Nagrath, M Gopal, "Control Systems Engineering", New Age International, 3rd Edition, 2007. |
| 3 | John W. webb, Ronald A.Reis, "Programmable Logic Controllers, Principles and Applications",5th Edition, 2002. |
| 4 | A Nagoor Kani, "Control Systems", RBA Publications,1st Edition, 2009. |

**REFERENCES:**

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|---|---|
| 1 | Benjamin Kuo, "Automatic Control Systems", PHI, 7th Edition, 1987. |
| 2 | K Ogata, "Modern Control Engineering", Prentice Hall, 4th Edition, 2003. |

## XIV. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

| Week No | Topics to be covered | Course Learning Outcomes (CLOs) | Reference |
|---|---|---|---|
| 1 | Time response of second order system | CLO 1 | T1:4.4 |
| 2 | Transfer Function Of Dc Motor | CLO 2 | T4:1.7 |
| 3 | Perform the experiment on AC Servo Motor and to study its performance characteristics | CLO 3 | T4:2.6 |
| 4 | Effect Of Various Controllers on Second Order System | CLO 4 | T4:3.8 |
| 5 | Compensator Design-lead, lag and lead-lag | CLO 5 | T1:4.8 |

| Week No | Topics to be covered | Course Learning Outcomes (CLOs) | Reference |
|---|---|---|---|
| 6 | Temperature Controller | CLO 6 | T1:3.8 |
| 7 | Design and Verification Of Op-Amp Based PID Controller | CLO 7 | T1:3.8 |
| 8 | Stability Analysis Using Digital Simulation- Root Locus, Bode Plot, Nyquist and polar plots. | CLO 8 | T1:6.5 |
| 9 | State Space Model Using Digital Simulation | CLO 9 | T1:6.5 |
| 10 | Introduction to programmable logic controllers and applications | CLO 11 | T4 |
| 11 | Develop basic ladder diagrams truth tables, counter, blinking of lights ,control of water level using PLC | CLO 12 | T4 |
| 12 | Develop ladder diagrams for truth tables- AND,NAND,OR,NOR. | CLO 12 | T4 |
| 13 | Develop basic ladder diagrams for implementation of counter | CLO 12 | T4 |
| 14 | Develop basic ladder diagrams for blinking of lights ,control of water level using PLC | CLO 12 | T4 |

## XV. GAPS IN THE SYLLABUS - TO MEET INDUSTRY / PROFESSION REQUIREMENTS:

| S No | Description | Proposed actions | Relevance with POs | Relevance with PSOs |
|---|---|---|---|---|
| 1 | Describe the importance of PID controller for controlling the temperature of an oven | Laboratory Practices | PO 2, PO 3 | PSO 1 |
| 2 | Design of lead-lag compensator to improve stability of control system. | Projects | PO 3, PO4 | PSO 1 |
| 3 | Verify the stability of time invariant control system using root locus, bode plot, polar plot, nyquist criterions using MATLAB. | Calculations of the observations | PO 2,PO 5 | PSO 3 |
| 4 | Develop ladder diagrams, truth tables, counter, blinking of lights ,control of water level using PLC | Laboratory Practices | PO 2,PO 5 | PSO 3 |

**Prepared by:**
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**HOD, EEE**