Program Name : **Diploma in Industrial Electronics**

Program Code : **IE**

Semester : **Fourth**

Course Title : **Basic Control Systems**

Course Code : **22429**

1. RATIONALE

Diploma engineers (also called technologists) should be able to control the various parameters at desired value in industry. This course provides the students to understand and apply the concepts, principles and procedure of controlling various parameters in different processes in industry. Students will also able to apply the knowledge of given control systems for basic fault finding in industry.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Maintain the stabilityof control systems**.

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Identify the type of control systems.
b. Analyze the control system for different input signals.
c. Check the stability of the control systems.
d. Use relevant control action for controlling the processes.
e. Troubleshoot different components in the control systems.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme											
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

***Legends:** **L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** -Practical; **C** – Credit, **ESE** -End Semester Examination; **PA** - Progressive Assessment*

5. COURSE MAP(with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

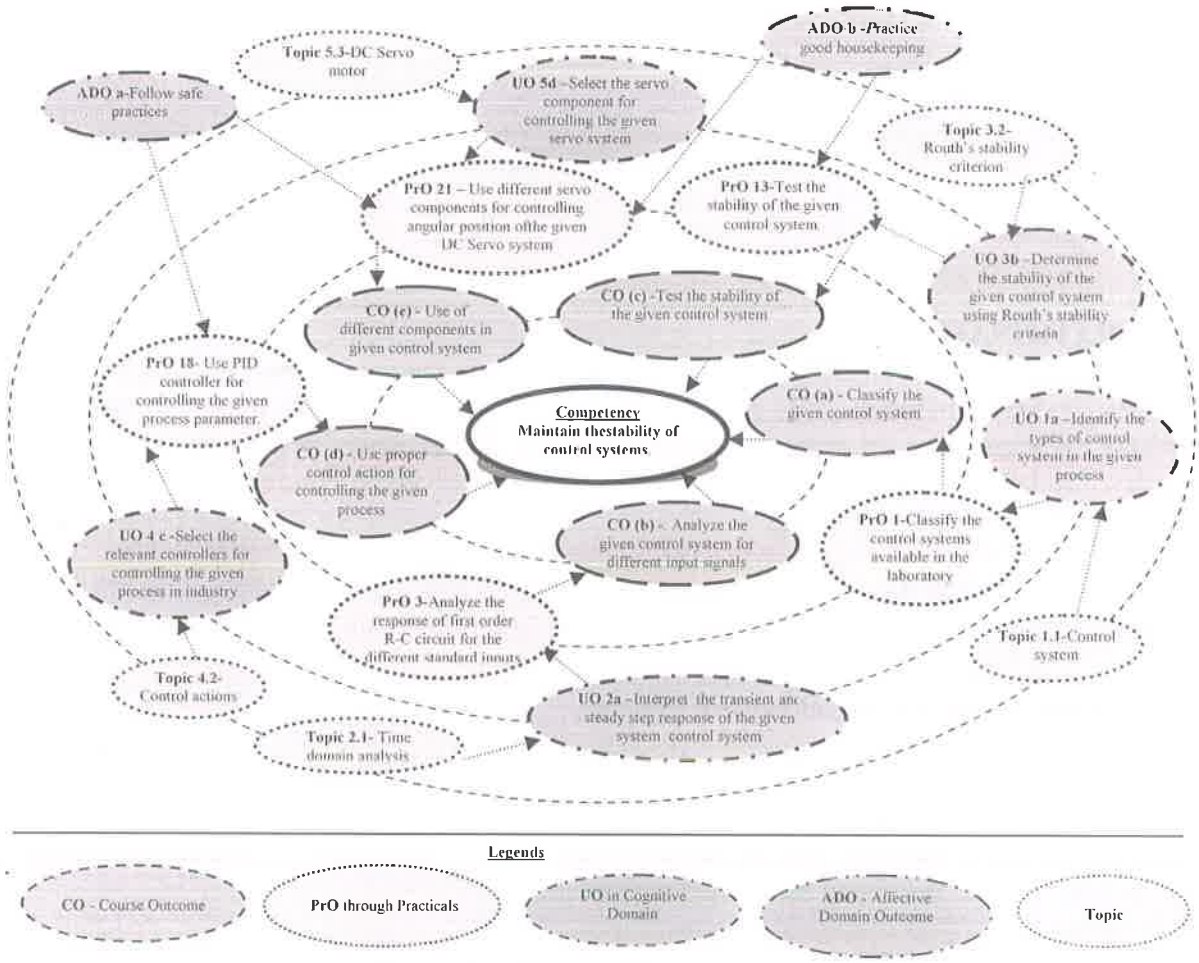

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Classify the control systems available in control system laboratory.	I	02
2	Use open source software for control system applications	-	02*
3	Interpret the response of first order R-C circuit for the different standard inputs.	II	02*
4	Interpret the response of first order RC circuit for the different standard inputs using open source software.	II	02
5	Interpret the response of second order R-L-C circuit for the different standard inputs.	II	02
6	Interpret the response of second order R-L-C circuit for the different standard inputs using open source software.	II	02
7	Interpret the given Type 0 of control system for step, ramp and parabolic inputs	II	02*
8	Interpret the given Type 0 of control system for step, ramp andparabolic inputs using open source software.	II	02
9	Interpret the given Type 1 of control system for step, ramp and parabolic inputs	II	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
10	Interpret the given Type 1 of control system for step, ramp and parabolic inputs using open source software.	II	02
11	Interpret the given Type 2 of control system for step, ramp and parabolic inputs	II	02*
12	Interpret the given Type 2 of control system for step, ramp and parabolic inputs using open source software.	II	02
13	Test the stability of the given control system using open source software.	III	02
14	Use ON-OFF controller for controlling the given process parameter.	IV	02*
15	TroubleshootProportional controller for controlling the given process parameter.	IV	02
16	Troubleshoot PI controller for controlling the given process parameter.	IV	02*
17	Troubleshoot PD controller for controlling the given process parameter.	IV	02*
18	Troubleshoot PID controller for controlling the given process parameter.	V	02*
19	Interpret the Characteristics of the given Potentiometer as error detector.	V	02
20	Interpret the Characteristics of the given Synchro as error detector.	V	02
21	Troubleshoot different servo components for controlling the angular position of the given DC Servo system	V	02*
22	Troubleshoot different servo components for controlling angular position of the given AC Servo system	V	02
23	Apply the generated pulses to the given stepper motor and measure its speed.	V	02
	Total		**46**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
1	Preparation of experimental set up	20
2	Setting and operation	20
3	Safety measures	10
4	Observations and recording	10
5	Interpretation of result and conclusion	20
6	Answer to sample questions	10
7	Submission of report in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safe practices
b. Practice good housekeeping
c. Practice energy conservation
d. Demonstrate working as a leader/a team member
e. Maintain tools and equipment
f. Follow ethical practices

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTSREQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Standard test signal kit: Generate Step, Ramp, Parabolic and Impulse signals	3,5,7,9,11,13
2	ON-OFF action of heater using on-off controller: heater, Temperature sensor , Relay	1,14
3	Proportional, P+I, P+D, P+I+D controllers: Electronic proportional action circuit provision to change PB, set point, integral time derivative time, heater, control valve.	1,15,16,17,18
4	Potentiometer characteristics and Potentiometer as an error detector: Two pairs of potentiometer with control to move wiper provision to measure output.	19
5	Synchro transmitter characteristics: Pair of Synchro provision to measure output	20
6	D.C. Position control system: Provision to transmit position	1, 21
7	A.C. Position control system: Provision to transmit position	1,22
8	Stepper motor: Permanent Magnet / Variable type reluctance motor provision to measure speed and direction.	23

8. UNDERPINNING THEORY COMPONENTS

The following topicsare to betaught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Fundament	1a. Identify the types of control system in the given process.	1.1 Control system: Classifications,concepts of positive

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
als of control systems	1b. Determine the transfer function of the given control system. 1c. Derive the transfer function forthe given control system. 1d. Describe using a block diagram reduction technique of the given control system. 1e. Describe with sketches the the procedure to troubleshoot the given simple control systems.	and negative feedback 1.2 Laplace Transform: Laplace Transform for standard functions. 1.3 Transfer function:Definition, Derivation. 1.4 R-C and R-L-C electrical circuits: Differential equations and transfer functions. 1.5 Order of a system: Zero, first and second order system, standard equations 1.6 Block diagram reduction technique:Need, reduction rules.
Unit-II Time response analysis	2a. Interpret the transient and steady step response of the given control system. 2b. Explain the significance of the given standard test inputs. 2c. Interpret the given first and second order control system for the givenstandard test input signals. 2d. Interpret the given control system using time response specification. 2e. Describe with sketches the the procedure to troubleshoot the given time response.	2.1 Time domain analysis: Transient and steady state response. 2.2 Standard test inputs:Step, Ramp, Parabolic and Impulse. 2.3 Polesand zeros:S-plane representation. 2.4 First order control system:Analysis for unit step input, Concept of time constant. 2.5 Second order control system: Analysis for unit step input, Concept, and effect of damping. 2.6 Time response specifications(no derivations) Tp, Ts, Tr, Td, Mp, Ess;. 2.7 Steady state analysis: 0, 1, 2 systems, Steady state error and error constants.
Unit– III StabilityAnalysis of Control System	3a. Explain with sketchesthe stability of the given control system. 3b. Determine the stability of the given control system using Routh's stability criteria. 3c. Determine the stability of the given control system using Bode plot. 3d. Describe the procedute to troubleshootthe stability of the given control system using frequency response specification.	3.1 Stability :Definition of stability, Analysis of Stable, unstable,critically stable and conditionally stable system, Relative stability, Rootlocations in S-plane for stable and unstable systems, conditions for unstable system. 3.2 Routh's stability criterion:Different cases and conditions (statementmethod). 3.3 Frequency Response Analysis:Concept, Advantages andDisadvantages, Frequency response specifications. Bode Plot Need, Straight lineMagnitude plot, Straight linephase angle plot, Bode plot for gain K, poles and zeros at origin of 1ST order system. Analyze

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		stability from Bode plot using Gain margin and Phase margin. 3.4 Methods of time domain and frequency domain for a response analysis
Unit– IV Process Control and Control actions	4a. Explain with sketches the control system for controlling the given process in industry. 4b. Describe with sketches the different control action to control the given process in industry. 4c. Select the relevant controllers for controlling the given process in industry with justification. 4d. Describewith sketches the specified controller for proper control action for controlling the process. 4e. Describe the procedute to troubleshoot the given Process Control.	4.1 Process control system: Block diagram and explanation of each block. 4.2 Control actions:Discontinuous (ON-OFF) and Continuous (proportional, integral and derivative) modes: Output equations, corresponding Laplace Transforms, Response graph. 4.3 Composite controllers: PI, PD, PID controllers- Output Equations, Response, Comparison, Application, and Electronic op-amp based circuits and tuning of PID controller
Unit –V Component of Servo systems	5a. Explainwith sketches the construction and working of the given type of servo system. 5b. Explain with sketches the working of the specifiedservo system components in servo systems. 5c. Select the relevant servo component for controlling the given servo systems with jsutification. 5d. Describe the procedute to troubleshoot the specified components of the given type of control system.	5.1 Servo system:Definition, block diagram 5.2 Potentiometer as error detector, Synchro as error detector, Stepper motor (PM and variable reluctance type). 5.3 DC servo motor- Characteristics, difference from a normal DC motor 5.4 Comparison of steppermotor with DC servo motor. 5.5 AC servo motor- Characteristics, difference from a normal 2 phase induction motor.

***Note**:To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FORQUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Fundamental of control system	10	04	04	06	14
II	Time response analysis	12	04	06	08	18
III	Stability and Methods of response analysis	10	02	04	06	12
IV	Process Control and Control actions	08	04	06	06	16
V	Components of Servo systems	08	02	04	04	10
Total		**48**	**16**	**24**	**30**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Prepare journals based on practical performed inlaboratory.
b. Library/Internet survey of different control systems
c. Prepare power point presentation or animation for understanding different control systems behavior.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the LOs/COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Use Flash/Animations to explain various theorems in circuit analysis
f. Guide student(s) in undertaking micro-projects

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***
The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.Micro project report may be of four to five pages.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. Prepare a report on the market survey for different controller avaibiltity.
b. Prepare a report on the market survey for different Servo components avaibiltity.
c. Visit nearby process industries and prepare a report on a different process available and control systems used to control it.
d. Visit nearby engineering institutes and prepare a report on different control systems available inthose institute laboratories.
e. Build / TestON-OFF controller for the given type of control loop.
f. Built / Test opamp based P controller for the given type of control loop.
g. Built / Test opamp based PI controller for the given type of control loop.
h. Built / Test opamp based PD controller for the given type of control loop.
i. Built / Test opamp based PID controller for the given type of control loop.
j. Built / Test Potentiometer as an error detector for the given control system.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Control System Engineering	Nagrath, I.J. ; Gopal, M.	New age International, New Delhi, 2008, ISBN: 9788122420081
2	Control Systems	Kumar, Anand	Prentice hall of India,NewDelhi,2014 ISBN:9788120349391
3	Control Systems	Varmah, K.R.	Tata McGraw Hill, New Delhi,2010 ISBN: 9780070678750
4	Modern Control Engineering	Ogata,K.	Tata McGraw Hill, New Delhi,2011 ISBN: 978-0136156734
5	Process Control Instrumentation Technology	Johnson,C. D.	PHI Learning, NewDelhi,2015 ISBN:978-9332549456
6	Control Engineering	Ramchndran,K.P.	Willey India, Delhi,2013 ISBN: 978-81-265-2288-0

S. No.	Title of Book	Author	Publication
7	Principles of Control Systems	Xavier , S.P. Eugene, Joseph	S. Chand, New Delhi,2016 ISBN:9788121917780
8	NISE'S Control Systems Engineering	Gupta,Rajeev	Willey India, Delhi,2011 ISBN:978-8126519477
9	Control System Engineering	Anandanatarajan,R.;Babu, Ramesh,P.	Scitech Publication, Chennai,2017 ISBN:9788183713603

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. www.nptel.ac.in/courses/108101037/
b. www.nptel.ac.in/courses/101108056/23
c. www.nptel.ac.in/courses/108101037/3
d. www.nptel.ac.in/courses/108101037/14
e. www.nptel.ac.in/courses/108101037/46
f. www.nptel.ac.in/courses/108105062/12
g. www.nptel.ac.in/courses/108101037/20
h. www.nptel.ac.in/courses/108103008/12
i. www.electrical4u.com/control-engineering
j. www.controlsystem.co.in/
k. www.automationfederation.org/filestore/af/resources/control
l. www.sc.iitb.ac.in


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