Program Name : **Electronics Engineering Programme Group**

Program Code : **DE/EJ/ET/EN/EX/EQ/IS/IC**

Semester : **Fifth**

Course Title : **Industrial Automation (Elective for DE/EJ/ET/EN/EX/EQ)**

Course Code : **22534**

1. RATIONALE

In the present global scenario of manufacturing, industries are moving towards complete automation. Small and medium scale industries are in the phase of switching to PLC and SCADA technology for the data acquisition and control. Therefore, it is necessary for Electronics/Instrumentation engineers to have knowledge of both PLC and SCADA technology. This course attempts to provide basic knowledge of these technologies to develop operational competency. Hence this course is foundation for the engineers who want to further specialize in the Industrial automation field.

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 Industrial Automation 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 different components of an automation system.
b. Interface the given I/O device with appropriate PLC module.
c. Prepare a PLC ladder program for the given application.
d. Select the suitable motor drives for the specified application.
e. Prepare a simple SCADA application.

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.

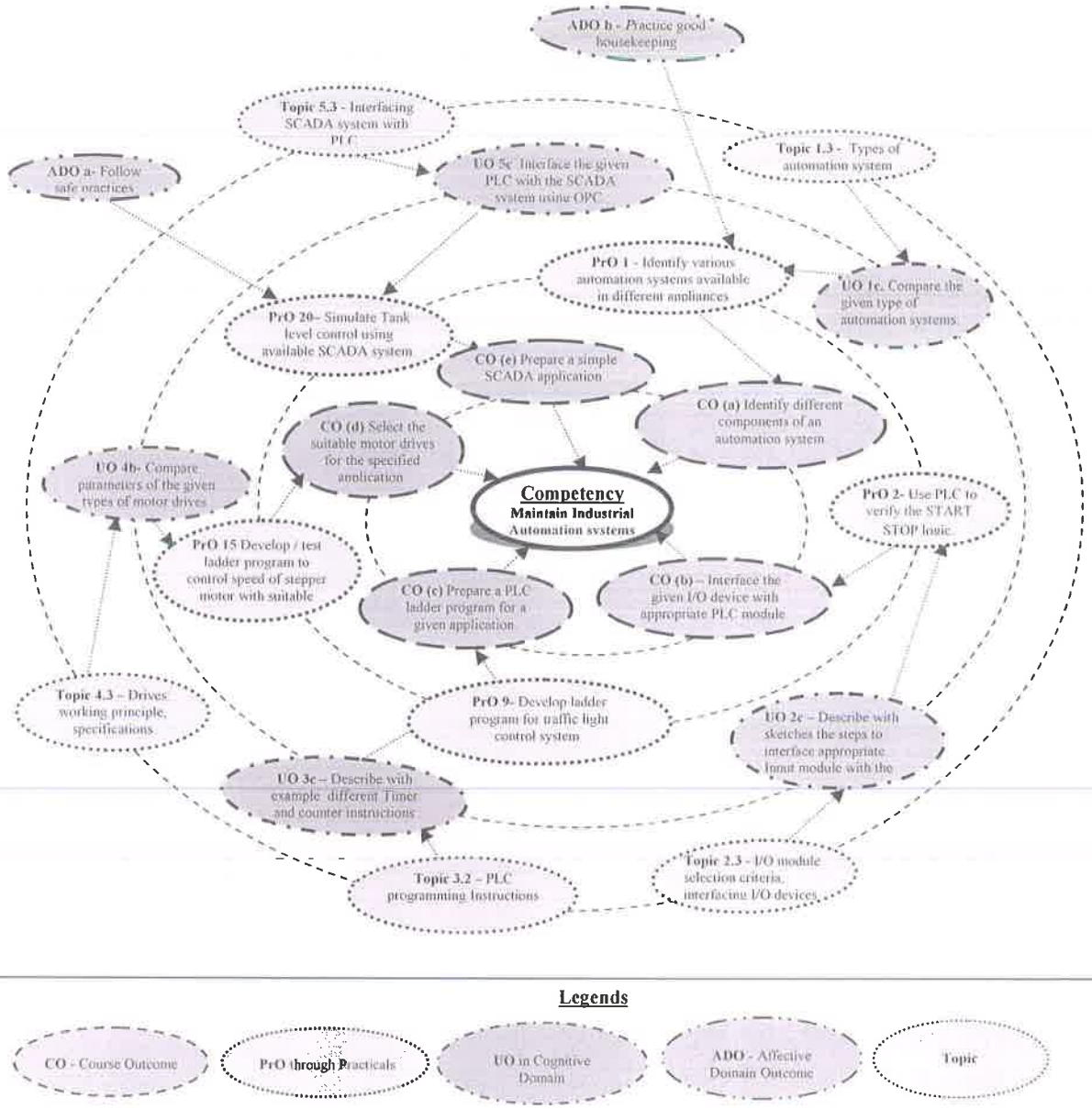

Figure 1 - Course Map

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	Identify various automation systems available in different appliances/devices/machines in day-to-day use.	I	02
2	Identify various parts and front panel status indicators of the given PLC.	II	02
3	Use PLC to test the START STOP logic for two inputs and one	II	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	output system.		
4	Develop/Execute a ladder program for the given application using following:- timer, counter, comparison, logical, arithmetic instructions.	II,III	02
5	Use PLC to control the following devices : lamp, motor, push button switches, proximity sensor	II,III	02
6	Measure temperature of the given liquid using RTD or Thermocouple and PLC.	II,III	02
7	Develop/test ladder program to blink LED/lamp.	III	02
8	Develop and test the Ladder program for sequential control application of lamps/ DC motors.	III	02
9	Develop and test ladder program for traffic light control system.	III	02
10	Develop and test ladder program for pulse counting using limit switch /Proximity sensor.	III	02
11	Develop /test ladder program for automated car parking system.	III	02
12	Develop / test ladder program for automated elevator control.	III	02
13	Develop / test ladder program for rotating stepper motor in forward and reverse direction at constant speed.	III	02
14	Develop /test ladder program for tank water level control.	III	02
15	Develop / test ladder program to control speed of stepper motor with suitable drivers.	IV	02
16	a. Identify various front panel controls of Variable Frequency Drive (VFD) (smart drive). b. Control speed of AC/DC motor using VFD.	IV	02
17	Use various functions of SCADA simulation editors to develop simple project.	V	02
18	Develop a SCADA mimic diagram for Tank level control.	V	02
19	Develop SCADA mimic diagram for Flow control of the given system.	V	02
20	Simulate Tank level control using available SCADA system.	V	02
	Total		**40**

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 %
a.	Preparation of experimental set up	20
b.	Setting and operation	20
c.	Safety measures	10
d.	Observations and Recording	10

S.No.	Performance Indicators	Weightage in %
e.	Interpretation of result and Conclusion	20
f.	Answer to sample questions	10
g.	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 safety practices.
b. Practice good housekeeping.
c. Practice energy conservation.
d. Work as a leader/a team member.
e. 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/ INSTRUMENTS REQUIRED

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	IEC 1131-3 compatible PLC with programming Software and interfacing hardware, user manual, (complete PLC Trainer system)	1
2	Input and Output devices for PLC: like Lamp, DC Motor, Proximity sensors, Thermocouple/RTD, Red, green, yellow LEDs, Stepper Motor, limit switches, push button	2,3,6
3	Nano PLC, Mini PLC, Micro PLC with analog and Digital I/O, memory, peripheral interfaces	1-16
4	Ladder logic simulator, Pico soft Simulator, Logixpro simulator, Simple EDA tools(open source)	1-13
5	Servomotor, DC motor, AC motor, steeper motor	14,15,16
6	Motor drives, drivers for special motors (VFD)	14,15,16
7	SCADA software: like Ellipse/FTVSE/Wonderware	14-16
8	Digital Multimeter (¾ Digital Multimeter): 4000 counts large LCD display with auto/manual range, No Power OFF under natural operation ,Data Hold, Max/Min value Hold Capacitance, Frequency/Duty Cycle	3 to 6

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught 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 Introduction to Industrial Automation	1a. Describe the benefits of the given Industrial automation system. 1b. Describe functions of the given components of automation system. 1c. Compare the characteristics of the given type of automation systems. 1d. Describe applications of the given automation system.	1.1 Need and benefits of Industrial Automation 1.2 Automation Hierarchy, Basic components of automation system, description of each component 1.3 Types of automation system:- Fixed, programmable, flexible 1.4 Different systems for Industrial automation: PLC, HMI, SCADA, DCS, Drives
Unit– II PLC Fundamentals	2a. Explain with sketches the redundancy concept for the given PLC. 2b. Identify the specified parts of the given PLC along with its function. 2c. Describe with sketches the steps to interface appropriate Input module of the given PLC with the given input device. 2d. Explain the criteria to select appropriate module for the given I/O devices. 2e. Describe with sketches the steps to interface appropriate output device with the given output module of the given PLC.	2.1 Building blocks of PLC: CPU, Memory organization, Input-output modules (discrete and analog), Special I/O Modules, Power supply 2.2 Fixed and Modular PLC and their types, Redundancy in PLC module 2.3 I/O module selection criteria Interfacing different I/O devices with appropriate I/O modules
Unit-III PLC Programming and Applications	3a. Specify the proper I/O addressing format of the given PLC. 3b. Explain the use of different relay type instructions for the given operation. 3c. Use timer and counter instructions to write a program to perform the given operation. 3d. Use Logical and Comparison instruction to write a program to perform the given operation. 3e. Describe with example the given type of data handling instructions. 3f. Describe the given elements of different programming languages used to program PLC. 3g. Develop PLC ladder program for the given simple application. 3h. Describe a PLC ladder program	3.1 PLC I/O addressing 3.2 PLC programming Instructions : Relay type instructions, timer instructions: On delay, off delay, retentive, Counter instructions, Up, Down, High speed, Logical instructions, Comparison Instructions, Data handling Instructions, Arithmetic instructions 3.3 PLC programming language– Functional Block Diagram (FBD), Instruction List, Structured text, Sequential Function Chart (SFC), Ladder Programming 3.4 Simple Programming examples using ladder logic: Language based on relay, timer counter,

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	for the given industrial application.	logical, comparison, arithmetic and data handling instructions 3.5 PLC based applications: Motor sequence control, Traffic light control, elevator control, Tank level control, conveyor system, Stepper motor control, reactor control
Unit – IV Electric Drives and Special Machines	4a. Describe with sketches the working of the given type of drive(s). 4b. State the functions of the given type of V/F converter. 4c. Compare given parameters of the specified type of motor drives. 4d. Describe the application of the given type of drive(s).	4.1 Electric drives: Types, functions, characteristics, four quadrant operation 4.2 DC and AC drive controls: V/F control, Parameters, direct torque control 4.3 Drives: working principle, specifications, parameters, types and applications 4.4 Applications- Speed control of AC motor /DC Motor
Unit-V Supervisory Control and Data Acquisition System	5a. Describe the function of the given element of SCADA. 5b. Describe the steps to develop a simple SCADA screen for the given application. 5c. Interface the given PLC with the SCADA system using OPC. 5d. Describe the steps to develop SCADA system for the given industrial application.	5.1 Introduction to SCADA, typical SCADA architecture/block diagram, benefits of SCADA 5.2 Various editors of SCADA 5.3 Interfacing SCADA system with PLC: Typical connection diagram, Object linking and embedding for Process Control(OPC) architecture, Steps in Creating SCADA Screen for simple object, Steps for Linking SCADA object (defining Tags and items) with PLC ladder program using OPC 5.4 Applications of SCADA: Traffic light control, water distribution, pipeline control

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 FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction to Industrial Automation	04	02	04	-	06
II	PLC Fundamentals	12	04	06	08	18

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
III	PLC Programming and Applications	16	04	06	12	22
IV	Electric Drives and Special Machines	08	02	04	06	12
V	Supervisory Control and Data Acquisition System	08	02	04	06	12
Total		**48**	**14**	**24**	**32**	**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. Do the internet survey and make a list of leading manufactures of the PLC, SCADA, DCS, HMI and other industrial automation tools with their brand name.
b. Refer operating manual of the PLCs of reputed Manufactures and prepare a step by step procedure to use PLC for the specified application.
c. Prepare a Power point presentation on the troubleshooting techniques of PLC.
d. Prepare the safety precautions list to be followed for installation of PLC system.
e. Download animated videos from the internet for any theory topic and make presentation on it.
f. Prepare a list of available analog input /output devices, digital input /output devices available in the market.
g. Guide the students for steps to be followed to configure available SCADA software.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES

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 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. Guide student(s) in undertaking micro-projects.
f. Students can participate in the online industrial automation forums.

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 is 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.

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

a. **Automatic street light controller:** Prepare a PLC based system to control the street light as per the intensity of natural light.
b. **Automatic agriculture irrigation system:** Prepare a PLC based system to control drip irrigation.
c. **Railway gate automation:** Prepare a PLC and SCADA based system to open or close the proto type railway gate automatically.
d. **Home automation:** Implement the versatile automation system for home that can automate any three home appliances.
e. **Bottle filling station:** Prepare a PLC and SCADA based system for proto type bottle filling station.
f. **Troubleshoot the Faulty Equipment/Kit available in automation Laboratory.**

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Programmable Logic Controller	Jadhav, V. R.	Khanna publishers, New Delhi, 2017, ISBN : 9788174092281
2	Programmable logic controllers	Petruzella, F.D.	Tata – McGraw Hill India, New Delhi, Fourth edition,2010, ISBN: 9780071067386
3	Programmable logic controllers and Industrial automation An introduction	Mitra, Madhuchandra; Sengupta, Samarjit	Penram International Publication, New Delhi, 2015, Fifth reprint, ISBN: 9788187972174
4	Introduction to Programmable logic controllers	Dunning, G.	Thomson /Delmar learning, New Delhi, 2005, ISBN 13 : 9781401884260
5	Supervisory control and Data acquisition	Boyar, S. A.	ISA Publication New Dxelhi (4th edition) ISBN: 978-1936007097
6	Programmable logic controllers	Hackworth, John; Hackworth, Federic	PHI Learning, New Delhi, 2003 ISBN : 9780130607188

S. No.	Title of Book	Author	Publication
7	Industrial automation and Process control	Stenerson, Jon	PHI Learning, New Delhi, ISBN : 9780130618900
8	Practical SCADA for Industry	Bailey, David ; Wright, Edwin	Newnes (an imprint of Elsevier)international edition, 2003 ISBN: 0750658053

14. SOFTWARE/LEARNING WEBSITES

a. Software:- www.fossee.com
b. Software:- www.logixpro.com
c. Software:- www.plctutor.com
d. Software;-www.ellipse.com
e. PLC lecture:- https://www.youtube.com/watch?v=pPiXEfBO2qo
f. PLC tutorial:-http://users.isr.ist.utl.pt/~jag/aulas/api13/docs/API_I_C3_3_ST.pdf


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