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 present global scenario of manufacturing, industries are moving towards complete automation. Small and medium scale industries require PLC and SCADA technology for the data acquisition and control. Therefore, it is necessary for instrumentation / electronics 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 make carrier in industrial automation.

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

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.

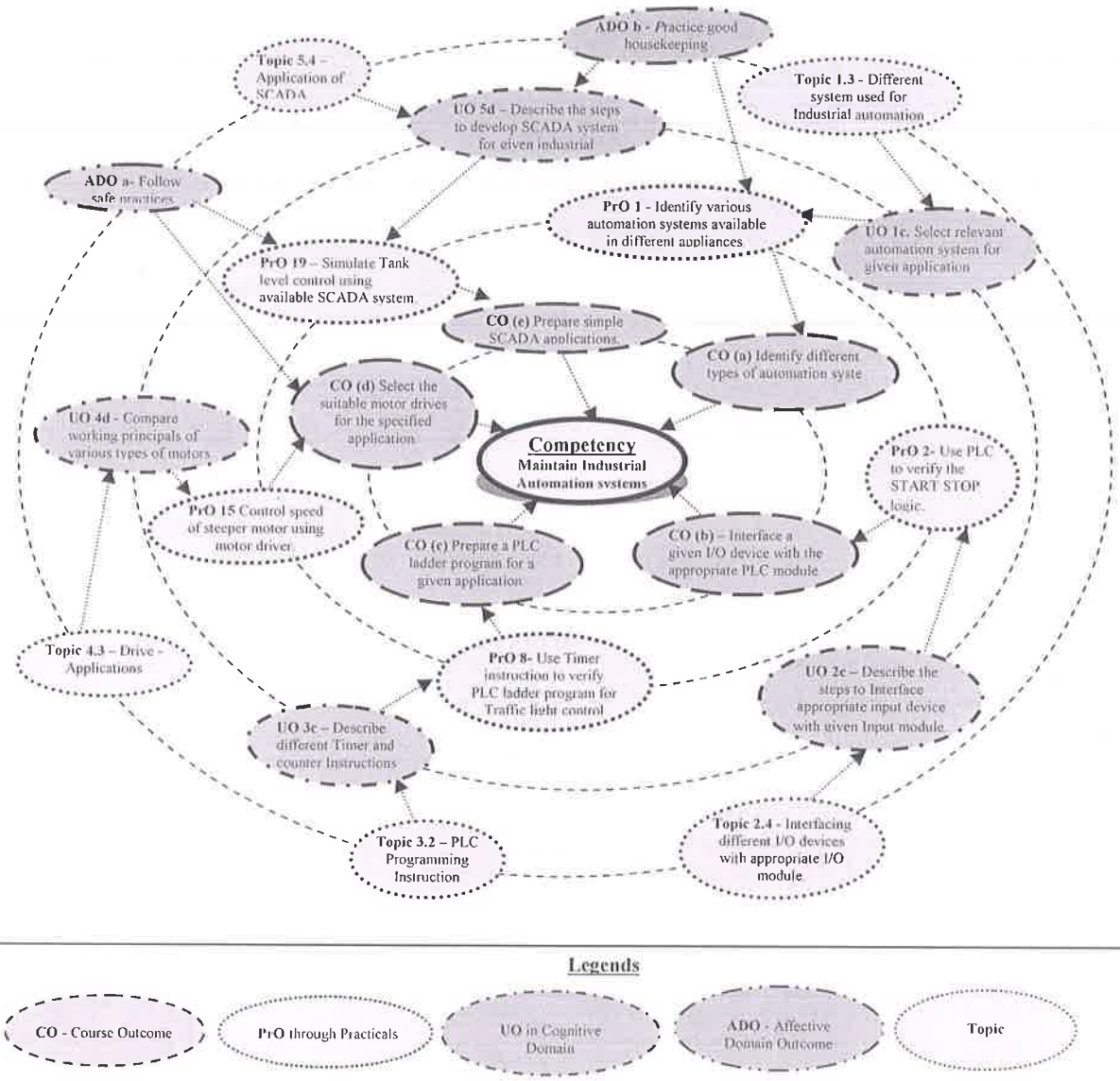

Figure 1 - Course Map

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 of the given PLC and front panel status indicators.	II	02
3	Use PLC to test the START STOP logic using two inputs and one output.	II	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
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 like lamp, motor, push button switches, proximity sensor	II,III	02
6	Measure the temperature of the given liquid using RTD or Thermocouple and PLC.	II,III	02
7	Develop/test ladder program to blink the LED/lamp.	III	02
8	Develop / test the Ladder program for sequential control application of lamps/ DC motors.	III	02
9	Develop 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 for control of speed of stepper motor with suitable drivers.	IV	02
16	a. Identify various front panel controls of VFD (smart drive). b. Control speed of AC/DC motor using VFD.(VFD-Variable Frequency Drive)	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 in a 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
e.	Interpretation of result and Conclusion	20

S.No.	Performance Indicators	Weightage in %
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. Demonstrate working 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, Using Simple EDA tools	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 etc.	14-16

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. Compare the features of the given type of automation system. 1b. Explain with sketches the working of the given type of automation system 1c. Select relevant automation system for the given application with justification 1d. Describe the features of the given stage of the PLC evolution	1.1 **Automation**: Need and benefits. 1.2 **Types of automation system:** Fixed, Programmable, Flexible 1.3 **Different systems used for Industrial automation:** PLC, HMI, SCADA, DCS, Drives. 1.4 Evolution of PLC.
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 relevant Input module with the given input device. 2d. Describe with sketches the steps to interface relevant output device with given output modules. 2e. Explain the criteria to select relevant module for the given I/O devices.	2.1 **Building blocks of PLC:** CPU, Memory organization, Input-output modules (discrete and analog), Specialty 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 2.4 Interfacing different I/O devices with appropriate I/O modules
Unit-III PLC Programming and Applications	3a. Specify the proper I/O addressing format for the given type of PLC. 3b. Describe with sketches the given type of relay instructions. 3c. Describe with sketches the given type of Timer Instructions. 3d. Describe with sketches the given type of counter Instructions. 3e. Describe with sketches the given type of instruction. 3f. Describe with sketches the given type of data handling instructions. 3g. Describe the elements of the given type of programming languages used to program PLC. 3h. Develop PLC ladder program for the given simple example. 3i. Develop a PLC ladder program for the given industrial application	3.1 PLC I/O addressing 3.2 **PLC programming Instructions:** Relay type instructions: No, NC, Latch, Unlatch, One Shot, Timer instructions: On delay, off delay, retentive, Timer reset, Counter instructions: Up, Down, High speed counter, Counter reset, Logical instructions, Comparison Instructions, Data handling Instructions: Move, Masked Move, Limit, Arithmetic instructions, Sequencer Instructions, PID Instruction, Scale with parameter instruction. 3.3 **PLC programming language:** Functional Block Diagram (FBD), Instruction List. Structured text, Sequential Function Chart (SFC), Ladder Programming. 3.4 **Simple Programming**

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		examples using ladder logic: Language based on relay, timer counter, 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 drives. 4b. Compare the salient features of the different types of motors drives. 4c. State the functions of given parameters of VFD. 4d. Describe the given application of Drives.	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:** Specifications, Applications- Speed control of AC motor /DC Motor.
Unit-V Supervisory Control and Data Acquisition System (SCADA)	5a. Describe the function of the given element of SCADA. 5b. Describe the steps to develop a simple SCADA screen for a given application. 5c. Interface the given PLC with the SCADA system using OPC. 5d. Describe the steps to develop SCADA system for 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 & 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	04	02	04	-	06

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
	Automation					
II	PLC Fundamentals	12	04	08	08	20
III	PLC Programming and Applications	16	06	08	12	26
IV	Electric Drives and special machines	08	02	04	04	10
V	Supervisory Control and Data Acquisition System	08	02	02	04	08
Total		48	**16**	**26**	**28**	**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. Read an operating manual of the PLCs of reputed Manufactures.
c. Prepare a Power point presentation on the troubleshooting techniques of PLC.
d. Read the safety precautions 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 (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 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 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 bottle filling.
f. Troubleshoot the Faulty Equipment/Kit available in automation Laboratory

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Introduction to Programmable logic controllers	Dunning, G.	Thomson /Delmar learning, New Delhi, 2005,ISBN 13 : 9781401884260
2	Programmable Logic Controller	Jadhav, V. R.	Khanna publishers, New Delhi, 2017, ISBN : 9788174092281
3	Programmable logic controllers	Petruzella, F.D.	McGraw Hill India, New Delhi, 2010, ISBN: 9780071067386
4	Programmable logic controllers	Hackworth, John; Hackworth, Federic	PHI Learning, New Delhi, 2003 ISBN : 9780130607188
5	Industrial automation and Process control	Stenerson Jon	PHI Learning, New Delhi, 2003 ISBN : 9780130618900
6	Programmable logic controllers and Industrial automation An introduction	Mitra, Madhuchandra; Sengupta, Samarjit	Penram International Publication, 2015, ISBN: 9788187972174
7	Supervisory control and Data acquisition	Boyar, S. A.	ISA Publication, USA ISBN: 978-1936007097

S. No.	Title of Book	Author	Publication
8	Practical SCADA for industry	Bailey David ; Wright Edwin	Newnes (an imprint of Elsevier), UK 2003, ISBN: 0750658053

14. SOFTWARE/LEARNING WEBSITES

a. Software:- www.fossee.com
b. www.logixpro.com
c. www.plctutor.com
d. www.ellipse.com
e. www.instrumentationengineers.org
f. PLC tutorial:-http://users.isr.ist.utl.pt/~jag/aulas/api13/docs/API_I_C3_3_ST.pdf