Program Name : **Electrical Engineering Program Group**

Program Code : **EE/EP/EU**

Semester : **Fifth**

Course Title : **Elements of Industrial Automation (Elective)**

Course Code : **22526**

1. RATIONALE

This course aims to acquaint students with vital components of automation such as motor control circuits, typical input/output devices, Programmable Logic Controller (PLC), Distributed Control System (DCS), Supervisory Control and Data Acquisition (SCADA) and Human Machine Interface (HMI). This will facilitate students to develop understanding and skills related with operation and maintenance of basic building blocks of industrial automation, which will in turn enable them to effectively upkeep the automated systems 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 PLC related 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. Maintain the relevant input/output components in industrial control circuits.
b. Wire PLCs for different applications.
c. Troubleshoot the PLC ladder programs for simple applications.
d. Test the PLC program in different applications.
e. Maintain the DCS and SCADA for different 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.

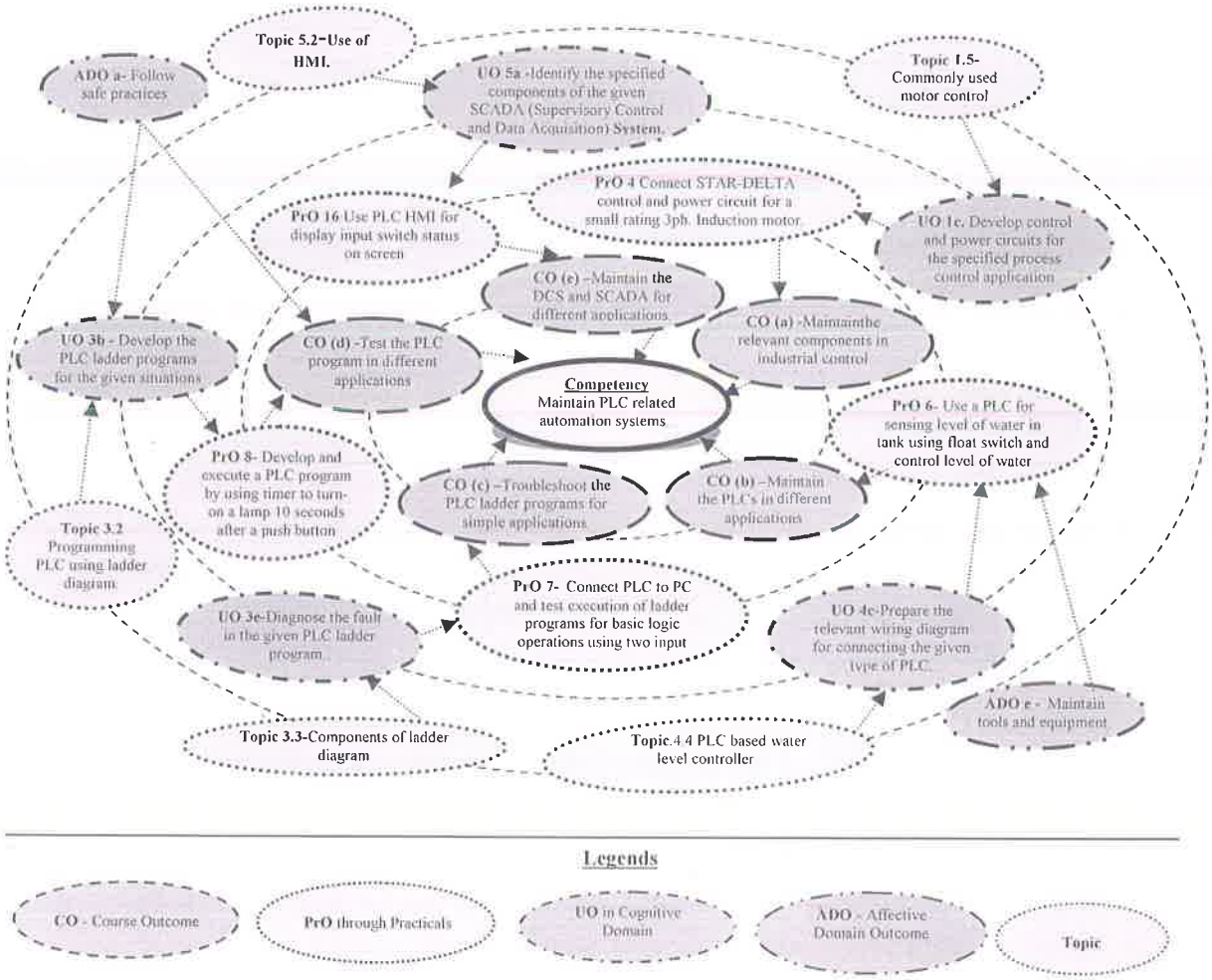

Figure 1 - Course Map

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 symbols in industrial control diagrams.	I	02*
2	Connect DOL starter control and power circuit for small rating 3ph Induction motor.	I	02*
3	Connect FOR-STOP-REV control and power circuit for a small rating 3ph Induction motor.	I	02*
4	Connect STAR-DELTA control and power circuit for a small rating 3ph. Induction motor.	I	02*
5	Simulate a simple seal-in circuit using PLC simulator.	III	02*
6	Connect PLC to PC and test execution of ladder programs for basic logic operations using two input switches and one output indicating lamp.	III	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
7	Execute a PLC program by using timer to turn-on a lamp 10 seconds after a push button press.	III	02*
8	Execute the PLC program by to count number of push button press events and display the same on screen.	III	02*
9	Connect PLC for STAR-DELTA staring of 3ph. Induction motor and test the ladder program for the same.	III	02
10	Connect PLC for FOR-STOP-REV control of 3ph. Induction motor and test the ladder program for the same.	III	02*
11	Use the PLC for running a stepper motor in clock-wise/anti-clock wise direction.	IV	02*
12	Use the PLC for sensing level of water in tank using float switch and control level of water using ON/OFF solenoid valve.	IV	02*
13	Use PLC for ON/OFF temperature control.	V	02
14	Use PLC for simulating traffic light control.	V	02
15	Use PLC HMI for display input switch status on screen.	V	02*
	Total		**30**

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.	Programming PLC and diagnose fault in the same.	30
c.	Observations and Recording	05
d.	Interpretation of result and Conclusion	05
e.	Answer to sample questions	20
f.	Submission of report in time	10
g.	Safety measures	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	Control components: Push buttons (5 NOS), indicating lamps (5 NOS), float switch (2 NOs)	2 to 16
2	Three phase AC contactors (2 NOS)	2 to 16
3	Small rating (< 1HP) three phase Induction motor.	2 to 16
4	PLC with min 8 I/Os and HMI and its simulation/programming software.(1 No.)	2 to 16
5	Stepper motor drive module.	2 to 16
6	Traffic light simulation practical model.	2 to 16
7	Temperature control system.	2 to 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 Industrial control circuits	1a. Identify a specified symbols along with their functions in the given industrial control diagram 1b. Explain with sketches the control and power circuit for the given motor control application. 1c. Develop control and power circuits for the specified process control application(s). 1d. Describe the method to troubleshoot the given industrial control circuit.	1.1 Need and benefit of automation, Different input devices such as push button, selector switch, limit switch, proximity switch and pressure switch. 1.2 Different output devices such as relay, contactor, solenoid valve, solid state relay (SSR) 1.3 Different symbols used in industrial control circuits. Concept of control and power circuit diagram. 1.4 Commonly used motor control circuits such as a) DOL starting b) Star-delta starter c) FWD-STOP-REV control and random reversing of induction motor.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		d) Soft Starters 1.6 Typical control and power circuit diagrams of hoist control, conveyer control, lifting magnet and Mill & Extruders.
Unit– II PLC Fundamentals	2a. Describe with sketches the function of a given part of PLC. 2b. Describe the function of the specified part of the given discrete IO module. 2c. Describe the function of the specified part of the given analog IO module. 2d. Describe the functions of the specified part of the given special IO modules. 2e. Compare the salient features of the given two PLCs using block diagrams.	2.1 Function of different parts of PLC such as CPU, memory, power supply and IO modules. 2.2 Digital IO module of PLC, Block diagram and specification 2.3 Analog IO module of PLC, Block diagram and specification 2.4 Special modules of PLC: Communication module PID controller module Stepper motor control module. 2.5 PLCs in market based on CPU type, no of IOs, speed and memory 2.6 Micro PLCs
Unit-III PLC Programming basics	3a. Identify the given parts of the ladder diagram along with the description their functions. 3b. Develop the PLC ladder programs for the given situations. 3c. Describe program scan process for the given type of PLC 3d. Modify the given relay instructions for proper implementation of the given ladder diagram. 3e. Describe the method to troubleshoot the given simple PLC ladder program.	3.1 Binary system, bit, byte, word, logic gates 3.2 Programming PLC using ladder diagram, Components of ladder diagram, Program scan process applied to single rung. 3.3 Ladder diagram for different logic gates. 3.4 Relay type instructions: IF-CLOSED, IF-OPEN Output Energize instructions. Internal relay instructions. 3.7 Timer/counter module: types of timers and counters
Unit –IV PLC Wiring diagrams and Ladder logic	4a. Develop ladder diagrams for the given situation(s). 4b. Select the relevant Input / Output devices required for the given application(s) with justification. 4c. Prepare the relevant wiring diagram for connecting the given type of PLC. 4d. Describe the method to troubleshoot the given PLC ladder	4.1 Seal in circuits using PLC 4.2 Ladder and wiring diagram of DOL starter with OLR 4.3 Latching Relay using PLC 4.4 PLC based water level controller. 4.5 Forward reverse control of 3-phase IM using PLC 4.6 Temperature control ON/OFF 4.7 Stepper motor control. 4.8 Bottle filling system.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	diagram and wiring diagram	4.9 Traffic light control
Unit-V SCADA and DCS	5a. Identify the specified components of the given SCADA System. 5b. Prepare a block diagram of the given architecture of SCADA. 5c. Identify the specified components in the given DCS diagram. 5d. Compare the salient features of given types of SCADA and DCS systems using block diagrams.	5.1 SCADA (Supervisory Control and Data Acquisition) overview. 5.2 Use of HMI. 5.3 SCADA architecture: Monolithic, distributed and networked. 5e. Concept of DCS (Distributed Control System)

***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	Industrial control circuits	08	02	06	08	16
II	PLC Fundamentals	10	02	04	08	14
III	PLC Programming basics	10	02	04	08	14
IV	PLC Wiring diagrams and Ladder logic	15	04	06	08	18
V	SCADA and DCS	05	02	02	04	08
Total		48	**12**	**22**	**36**	**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) Visit any manufacturing plant having PLC automation.
b) Visit any manufacturing plant with SCADA, HMI.
c) Make a survey of industrial control components based on their ratings.
d) Make a survey of commercially available PLCs.
e) Library / Internet survey of industrial automation circuits and systems.
f) Prepare power point presentation or animation on different automation circuits and their 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 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) Correlate each topic and subtopics with requirement of automation in industrial environment.
g) Use proper equivalent analogy to explain different concepts.
h) Use PLC simulation software to exhibit mimic of an industrial problem.

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.

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

a) PLC based induction motor control circuit.
b) PLC based servo motor control.
c) PLC based stepper motor control.
d) PLC based safety system.
e) PLC based closed loop temperature control system.
f) PLC based object counting system.
g) PLC based conveyer control system.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Handbook of Electrical Motor Control Systems	Eswar, U.S.	McGraw Hill Education, New Delhi, 2013, ISBN : 9780074604380
2	Control of Machines	Bhattacharya,	New Age International Publishers,

S. No.	Title of Book	Author	Publication
		S.K.; Singh, B.	New Delhi, 2006, ISBN: 978122418187
3	Programmable Logic Controllers – Principles and Applications	Webb, J.W; Reis,R.A.	PHI learning Pvt. Ltd., New Delhi, 2003; ISBN : 9780130416728
4	Programmable Logic Controllers	Hackworth, J.R.; Hackworth, F.	Pearson Education, New Delhi, 2015, ISBN : 9788177587715
5	Programmable Logic Controllers	Petruzella, F.D.	McGraw Hill Education(India) Edition, New York, 2016, ISBN: 9780073510880
6	Programmable Logic Controllers	Bolton, W.	Elsevier India Pvt, Ltd. New Delhi, 2016, ISBN: 9780128029299
7	Introduction to PLC	Dunning, G.	Cengage India (2009), ISBN: 9788131503027

14. SOFTWARE/LEARNING WEBSITES

a. http://electrical-engineering-portal.com/resources/plc-programming-training
b. PLC Basic Fundamentals and Wiring (Hindi): https://www.youtube.com/watch?v=g7ONCWmRy0w
c. Programmable Logic Controller Basics PLC Professor: https://www.youtube.com/watch?v=PLYosK87D8E
d. Basics of PLC ladder diagram: https://www.youtube.com/watch?v=Hci-eW5IihM
e. Controlling water level by using PLC: https://www.youtube.com/watch?v=1pRv-p_HbRk
f. Traffic signal control using PLC: https://www.youtube.com/watch?v=3WATUnwCwRA
g. Bottle Filling Process using PLC: https://www.youtube.com/watch?v=8UQOhGp8gqY