Program Name : **Diploma in Industrial Electronics**

Program Code : **IE**

Semester : **Sixth**

Course Title : **PLC and SCADA**

Course Code : **22640**

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 electronics engineers to have knowledge of both PLC and SCADA technology. This course attempts to provide basic configurationally knowledge of these technology to develop operational competency. Hence this course is foundation for the engineers who want to specialize in PLC and SCADA.

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 PLCs and SCADA systems used in different applications.**

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 PLC.
b. Select appropriate PLC modules for given application.
c. Develop PLC ladder program for a given application.
d. Test a simple SCADA application
e. Test a simple PLC-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
4	-	2	6	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.

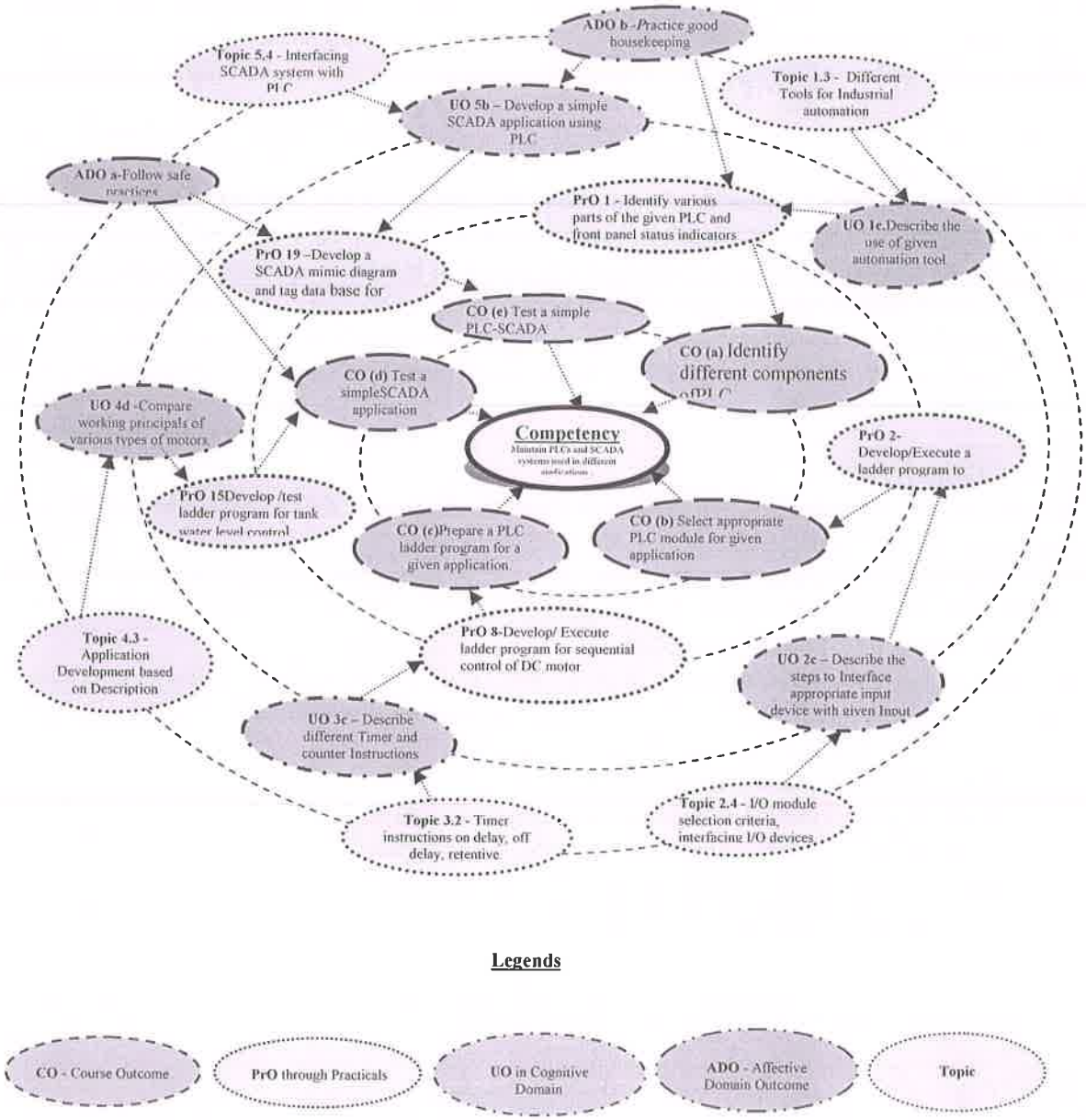

Figure 1 - Course Map

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 parts of the given PLC and front panel status indicators.	I, II	02*
2	Develop/Execute a ladder program to Verify functions of Logic gates	III	02*
3	Develop/Execute a ladder program to verify 4:1 MUX and 1:4	III	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	DEMUX		
4	Develop/Execute a ladder program to test the START STOP logic using two inputs and one output.	III	02*
5	Develop/Execute a ladder program for blinking of LEDs.	III	02
6	Develop/Execute a ladder program for sequential ON-OFF control of lamps.	III	02*
7	Develop/ Execute ladder program for sequential control of DC motor.(Condition1)	III	02
8	Develop/ Execute ladder program for sequential control of DC motor (use T OFF instruction).	III	02
9	Develop/ Execute 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/ Execute ladder program for temperature ON-OFF control.	II,III	02*
12	Develop/ Execute ladder program for washing system.	III	02*
13	Develop/ Execute ladder program for conveyor system.	III	02
14	Develop/ Execute ladder program for elevator system.	III	02
15	Develop /test ladder program for tank water level control.	III	02
16	Develop /test ladder program for air conditioner system .	III	02
17	Use various functions of SCADA simulation editors to develop simple project.	IV, V	02*
18	Develop a SCADA mimic diagram and tag database for On-Off control of lamp	V	02*
19	Develop a SCADA mimic diagram and tag database for Traffic light control system	V	02
20	Develop a SCADA mimic diagram and tag database for conveyor system	V	02
21	Create trend for any one application for above experiment	IV, V	02*
	Total		**42**

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, collection of data 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. 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	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, limit switches, push button.	5,6,7
3	Nano PLC, Mini PLC, Micro PLC with analog and Digital I/O, memory, peripheral interfaces	1-23
4	Ladder logic simulator, Pico soft Simulator, Logixpro simulator, Using Simple EDA tools	2-23
5	SCADA software: like Ellipse/FTVSE/**Wonderware**etc.	24-33

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopicsshould betaught and assessed in order to develop UOs for achieving the COs to attain the identified competency.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– I Introductio n to PLC	1a.Identify the specified parts of the given PLC along with its function. 1bIdentify different Programming devices types. 1c. Differentiate different types of PLCs 1d.Explain with sketches the redundancy concept for the given PLC.	1.1 Need and benefits of Automation. 1.2 Tools of Automation: PLC, SCADA, HMI, DCS, Drives. 1.3 PLC Architecture: Block diagram, working. CPU: function, scanning cycle, speed of execution Memory: organization and function. Input- output modules: discrete and analog, Specialty I/O Modules. Power supply: Block diagram, Working 1.4 PLC Type: Fixed PLC, Modular PLC. 1.5 Redundancy in PLC system 1.6 Advantages and Disadvantages of PLC
Unit– II PLC Hardware	2a. Identify and describe the given module of PLC 2b. Describe the given addressing of PLC 2c. Use instruction set to perform the given operation. 2d. Develop ladder logic programs for the given application. 2e. Describe with sketches the steps to interface appropriate Input module with the given input device.	2.1 Discrete input modules: AC input modules - block diagram, description, wiring details, and specifications. DC input modules - block diagram, description, wiring details, sinking and sourcing concept & specifications 2.2 Analog input modules- block diagram, description, interfacing of input devices & specifications. 2.3 Discrete output modules: AC output modules - block diagram, description, wiring, and specifications. DC output modules - block diagram, description, wiring details, sinking and sourcing concept & specifications. Relay and Isolated o/p modules 2.4 Analog output modules- block diagram, description, wiring details& specifications 2.5 I/O module selection criterion.
Unit-III PLC programmi ng and applications	3a. Specify the proper I/O addressing format for PLC. Describe the format of different relay type instructions. 3b. Describe the format of different Timer and counter Instructions. 3c. Describe the format of different	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

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	Logical and Comparison type instruction. 3d. Describe the format of different data handling instructions. 3e. Describe the elements of different programming languages used to program PLC. 3f. Develop PLC ladder program for the given simple example. 3g. Develop a PLC ladder program for the given industrial application	Instructions, Data handling Instructions, Arithmetic instructions, Sequencer instruction, PID 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: Based on relay, timer, counter, logical, comparison, arithmetic and data handling instructions ,PID, Sequencer instruction. 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 Introduction to SCADA	4a.Descibe applications of SCADA 4b. Describe the function of the given element of SCADA 4c. Describe SCADA configuration 4d. Differentiate SCADA and PLC	4.1 Introduction to SCADA, Application area of SCADA 4.2 SCADA architecture/block diagram, Benefits of SCADA. 4.3 Types of SCADA: • Single Master Single Remote • Single Master Multiple Remote • Multiple Master Multiple Remote 4.4 SCADA System Hardware, • Remote Terminal Units (RTUs), • Master Terminal Units(MTUs) • Communication system 4.5 Differentiate SCADA and PLC
Unit-V SCADA interfacing and Applications	5a Interface the given PLC with the SCADA system using OPC. 5b Describe the steps to develop SCADA system for given industrial application. 5c Describe the steps to develop a simple SCADA screen for a given application.	5.1 Interfacing SCADA system with PLC: Connection diagram, object linking and embedding for Process Control(OPC) architecture, 5.2 Steps in Creating SCADA Screen for simple object, Steps for Linking SCADA object (defining Tags and items) with PLC ladder program using OPC, 5.3 Concept of Tag, types of Tags,

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		addressing of Tags. 5.4 Alarm generation, trend types. 5.5 Applications of SCADA: On-Off control of lamp , Traffic light control, level control system, water distribution system, elevator system, conveyor 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 FORQUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction to PLC	08	02	04	--	06
II	PLC Hardware	14	04	10	--	14
III	PLC programming and applications	20	04	04	18	26
IV	Introduction to SCADA	08	02	06	--	08
V	SCADA interfacing and Applications	14	02	04	10	16
	Total	**64**	**14**	**28**	**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, with their brand name.
b. Read an operating manual of the PLCs of reputed Manufactures.
c. Download animated videos from the internet for any theory topic and make presentation on it.
d. Prepare a list of available analog input /output devices, digital input /output devices available in the market.
e. Prepare report on 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 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 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. **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.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Introduction to Programmable logic controllers	Dunning, G.	Thomson /Delmar learning, 2005,ISBN 13 : 9781401884260
2	Programmable Logic Controller	Jadhav, V. R.	Khanna publishers, 2017 ISBN : 9788174092281
3	Programmable logic controllers (Fourth edition)	Petruzella, F.D.	Tata – McGraw Hill India, 2010,ISBN: 9780071067386
4	Programmable logic controllers	Hackworth, John; Hackworth, Federic	Prentice hall publication, 2003 ISBN : 9780130607188

S. No.	Title of Book	Author	Publication
5	Industrial automation and Process control	Stenerson Jon	Prentice hall publication ISBN : 9780130618900
6	Programmable logic controllers and Industrial automation An introduction	Mitra, Madhuchandra; Sengupta, Samarjit	Penram International Publication, 2015, Fifth reprint, ISBN: 9788187972174
7	Supervisory control and Data acquisition	Boyar, S. A.	ISA Publication (4th edition) ISBN: 978-1936007097
8	Practical SCADA for industry	Bailey David ; Wright Edwin	Newnes (an imprint of Elsevier), 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