Program Name : **Diploma in Automation and Robotics**

Program Code : **AO**

Semester : **Fourth**

Course Title : **Advanced Automation System**

Course Code : **22475**

1. RATIONALE

In the present global scenario of manufacturing, industries are moving towards more and more automation. Small scale and medium scale industries require PLC and SCADA technology, So, it is very necessary for an Automation engineer to have knowledge of both PLC and SCADA. So, this course attempts to provide basic configurationally knowledge of these technologies to develop operational competency. Hence this course is very important for Automation engineers who want to specialize 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 Advanced Industrial Automation system.**

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. Compare different SCADA systems based on given parameters.
b. Use the relevant Network communication protocol for specific SCADA applications.
c. Develop SCADA based applications in integration with PLC.
d. Use the HMI Panel for given applications.
e. Use the SCADA system to develop the given industrial 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
4	-	2	6	3	70	28	30*	00	100	40	25#	10	25	10	50	20

(~): For the practical only courses, the PA has two components under practical marks i.e. components of the COs), to be developed and assessed in the student to lead to the attainment the assessment of practical's (seen in section 6) has a weightage of 60% (i.e.30 marks) and or the competency. micro-project assessment (seen in section 12) has a weightage of 40% (i.e.20 marks). This is designed to facilitate attainment of UOs holistically, as there is no theory

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 center of this map.

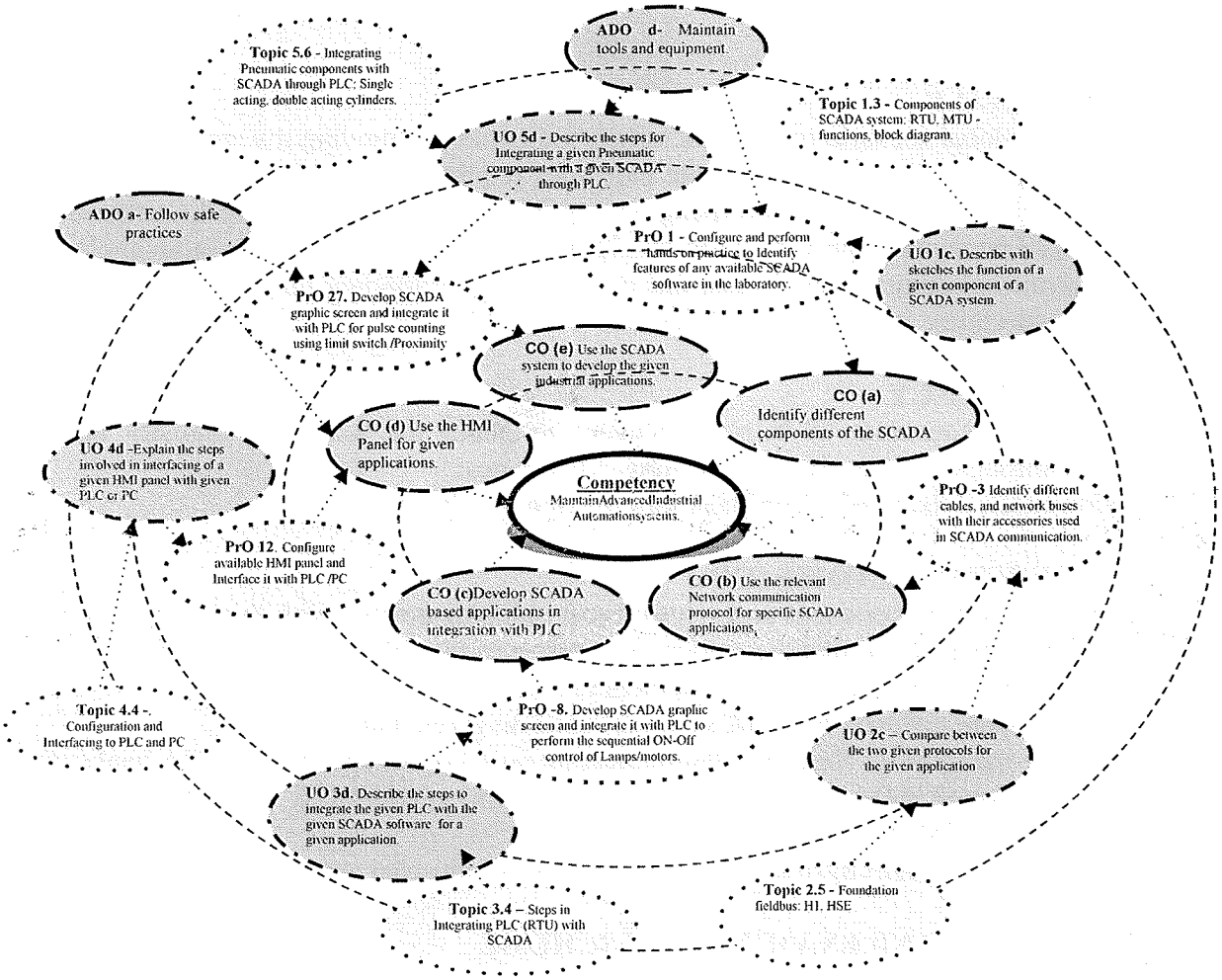

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practical 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	Configure and perform hands-on practice to Identify features of any available SCADA software in the laboratory.	I	02*

2	Identify different objects configuration, Dynamic properties (blinking, movement, filling etc.) in SCADA software.	I	02
3	Identify different cables, and network buses with their accessories used in SCADA communication.	II	02*
4	Interface the given Excel database sheet to the SCADA software using DDE connectivity.	II	02*
5	Configure and perform hands on practice to Identify various features of any available open source OPC DA Server software in the laboratory.	III	02*
6	Develop interconnection of a given PLC with the available SCADA software using OPC DA Server.	III	02*
7	Develop SCADA graphic screen and integrate it with PLC to perform START STOP logic using two push buttons and one lamp.	III	02
8	Develop SCADA graphic screen and integrate it with PLC to perform the sequential ON-Off control of Lamps/motors.	III	02*
9	Measure the temperature of a given liquid using RTD or Thermocouple and integrate it in SCADA using PLC.	III	02*
10	Configure the alarm and set a real time trend for the setup used in Experiment no.09.	III	02
11	Develop SCADA graphic screen and integrate it with PLC for pulse counting using limit switch /Proximity sensor.	III	02*
12	Configure available HMI panel and Interface it with PLC /PC	IV	02
13	Apply AND / OR logic using two manual controls for forward stroke of a double acting pneumatic cylinder.	V	02
14	Perform the operation of two double acting cylinders electro pneumatically (Sequence of motion: A+B+B-A-)	V	02
15	Develop and Test PLC program for Single and double Acting Pneumatic Cylinder using single solenoid valve and Inductive proximity sensors.	V	02*
16	Develop SCADA graphic screen and integrate it with PLC for the setup used in experiment no.15	V	02*
		Total	**32**

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 24 or more practical need to be performed, out of which, the practical 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 setup.	20
2	Setting and operation.	20
3	Safety measures.	10
4	Observation 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 safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
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
- 'Organizing Level' in 2nd year
- 'Characterizing 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.

Sr. No.	Equipment Name with Broad Specifications	PrOs Sr. No.
1	Computer system; Operating System: Windows 10 or higher Memory: minimum of 8 GB RAM, Minimum of Intel Core i3 or equivalent	All
2	IEC 1131-3 compatible PLC with programming Software and interfacing hardware, user manual.	5,7,12,16
3	Input and Output devices for PLC: like Lamp, DC Motor, Proximity	7,8,9,11

	sensors, Thermocouple/RTD, Red, green, yellow LEDs, limit switches, push button.	
4	IEC standard compatible latest version of SCADA/HMI software from any reputed manufacturer of SCADA like Ellipse/ VijeoCitect /Wonderware / RSView32 /WinCC / Cimplicity etc.	1-3,4-12, 16
5	Open source OPC DA Server software	4-12,16
6	Coaxial Cable, UTP Cable, STP Cable, Fiber Optic Cable	03
7	Electro Pneumatic Trainer Kit	13 -16
8	Electro-Pneumatic PLC trainer kit	13-16

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 Basics of SCADA System	**1a.** Explain with sketches the function of the given Automation Hierarchy levels **1b.** Describe with sketches the architecture of a SCADA system. **1c.** Describe with sketches the function of a given component of a SCADA system. **1d.** Compare the given SCADA software on the given parameters.	**1.1.**Recall - Knowledge of Industrial automation Hierarchy. **1.2.**Typical SCADA Architecture / layout diagram. **1.3.**Components of SCADA system: RTU, MTU -functions, block diagram. **1.4.**Commercially available SCADA Softwares : Intouch , Vijeocitect , Rsview32 (features, cost, network requirements, Specifications of these softwares)
Unit– II SCADA Network Communication	**2a.** Explain with sketches the specific network topology used in the SCADA system. **2b.** Identify the type of cables used in SCADA network communication. **2c.** Compare between the two given protocols for the given application. **2d.** Describe the process of DDE connectivity of a given database with the given SCADA system.	**2.1**Network topologies, Cables used in SCADA **2.2**Modes of Network communication: Master-slave, Bus arbitration, Token passing, random bus access ,CS(Client-server) **2.3**Modbus- TCP/IP, RTU **2.4**Profibus: PA, DP **2.5** Foundation fieldbus: H1, HSE **2.6** Database and DDE connectivity

Unit– III SCADA System Integration	**3a.** Describe the given feature of a given SCADA software. **3b.** Describe with sketches the working of the given type of drives. **3c.** Interface the given PLC with the SCADA system using the given OPC DA server. **3d.** Describe the steps to integrate the given PLC with the given SCADA software for a given application.	**3.1** SCADA Software- Creating graphics, Real time and Historical Trends, Alarms and Events,database of Tags, display charts, logs and reports, object Library (use of buttons, slider, pipe connection etc.). **3.2** Electric Drives: Need, types, block diagram, functions, characteristics, four quadrant operation. Comparison of AC/DC drives, VFD. **3.3** Introduction to OPC DA server (OLE for Process control) – functions, architecture. **3.4** Steps in Integrating PLC (RTU) with SCADA - Developing PLC Based Applications. - Configuring the OPC Data Access server - Creating Tags database - Configuring SCADA graphic objects, trends and alarms - SCADA runtime environment
Unit– IV Human Machine Interface (HMI)	**4a.** Identify the type of given HMI panel **4b.** Describe the wiring connection of a given HMI panel **4c.** Describe the operation of a given HMI panel **4d.** Explain the steps involved in interfacing of a given HMI panel with given PLC or PC	**4.1** Different types of operator Interfaces – Textual, Graphical **4.2** Connection Wiring of HMI **4.3** Data handling with HMI **4.4** Configuration and Interfacing to PLC and PC
Unit– V SCADA Application development	**5a.** Develop a ladder program for a given industrial application. **5b.** Develop a graphic screen for a given application using a given SCADA software. **5c.** Create a server configuration and tag database for a given SCADA based application using a given OPC DA Server. **5d.** Describe the steps for Integrating a given	**5.1** Robotic pick and place mechanism **5.2** Temperature control system **5.3** Car washing system **5.4** Sorting and Stacking system **5.5** Water level control system (study of PLC ladder program, OPC DA configuration, tag database, SCADA graphic screen for above examples) **5.6** Integrating Pneumatic components with SCADA through PLC: Single acting, double acting cylinders.

	Pneumatic component with a given SCADA through PLC.	

***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	Basics of SCADA System	10	4	6	--	10
II	SCADA Network Communication	14	4	4	6	14
III	SCADA System Integration	14	4	6	6	16
IV	Human Machine Interface (HMI)	10	4	6	--	10
V	SCADA Application development	16	--	8	12	20
	Total	**64**	**16**	**30**	**24**	**70**

***Legends:** R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
***Note**: This specification table provides general guidelines to assist students for their learning and to teachers to teach and assess students with respect to attainment of LOs. 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 manufacturers of the SCADA and other industrial automation tools with their brand name.
b. Read an operating manual of the SCADA of reputed Manufactures.
c. Prepare a PowerPoint presentation on the troubleshooting techniques of SCADA.
d. Read the safety precautions to be followed for installation of SCADA based application systems.
e. Download animated videos from the internet for any theory topic and make a presentation on it.
f. Prepare a list of available analog input /output devices, digital input /output devices available in the market.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

a. Massive open online courses (***MOOCs***) may be used to teach various topics/subtopics.
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/subtopics*** which are 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. Video programs/YouTube may be used to teach various topics and sub topics.
f. Demonstrate students thoroughly before they start doing the practice.
g. Encourage students to refer to differentbooks and websites to have a deeper understanding of the subject.
h. Observe continuously and monitor the performance of students in the Lab.
i. Encourage students to use front/rear panel control of electronic instruments.
j. Encourage students to visit nearby electronic instruments repair workshop units or manufacturing industries.
k. Instruct students to safety concerns of handling electronic instruments and also to avoid any damage to the electronic instruments.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student assigned to him/her in the ***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 preferably be ***individually*** undertaken to build up the skill and confidence in every student to become a 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 a 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 a 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 SCADA based system to control the street light as per the intensity of natural light.
b. **Automatic agriculture irrigation system:** Prepare a SCADA based system to control drip irrigation.
c. **Railway gate automation:** Prepare a 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 SCADA based system for bottle filling.
f. Troubleshoot the Faulty Equipment/Kit available in automation Laboratory.

13. SUGGESTED LEARNING RESOURCES

S.	Title of Book	Author	Publication

No.			
1	Supervisory control and Data acquisition	Boyar, S. A.	ISA Publication (4th edition) ISBN:978-1936007097
2	Practical SCADA for industry	Bailey David; Wright Edwin	Newnes (an imprint of Elsevier), 2003ISBN:0750658053
3	PLCs & SCADA - Theory and Practice	Rajesh Mehra, Vikrant Vij	Laxmi Publications Pvt Ltd; First editionISBN-10 : 9381159114
4	Instrument engineers' handbook: process software and digital networks	Béla G. Lipták	Published September 23, 2011 by CRC Press ISBN 9781439817766
5	Industrial automation and Process control	Stenerson Jon	Prentice hall publication ISBN: 9780130618900

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. https://www.matrikonopc.com/opc-server/opc-data-access-versions.aspx
b. https://www.opcconnect.com/opcintro.php
c. https://www.kepware.com/en-us/products/kepserverex/- for OPC software download.
d. http://thelearningpit.com/lp/logixpro.html
e. https://wonderware-intouch.software.informer.com/ for SCADA/ HMI software download
f. https://rslinx-classic.software.informer.com/
g. https://en.freedownloadmanager.org/Windows-PC/Vijeo-Citect-FREE.html