

Programme Name/s : Automation and Robotics
Programme Code : AO
Semester : Fourth
Course Title : AUTOMATION TOOLS & SYSTEMS
Course Code : 314335

I. RATIONALE

In the present global manufacturing scenario, industries are moving more and more toward automated operations. Knowledge and skill related with Advanced Automation Systems like Programmable Logic Controllers (PLCs), Supervisory Control and Data Acquisition (SCADA), Human Machine Interface (HMI) play a pivotal role in optimizing industrial processes by providing control, data acquisition capabilities and real-time monitoring. Understanding these systems is essential for Automation & Robotics engineering students, as it empowers them to design, implement, and secure interconnected systems that drive modern industries, fostering innovation, productivity, and safety.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the students to attend the following industry/ employer expected outcome through various teaching learning experiences:
Maintain industrial automation systems.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Describe the working of PLC with its structure.
- CO2 - Execute different PLC ladder programming instructions.
- CO3 - Maintain PLC for specific application.
- CO4 - Use SCADA and HMI with relevant network communication protocols.
- CO5 - Develop simple SCADA and HMI based applications.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme						Credits	Paper Duration	Assessment Scheme									
				Actual Contact Hrs./ Week			SLH	NLH	Theory			Based on LL & TL				Based on SL		Total Marks			
				CL	TL	LL						Practical				SLA					
				Max	Max	Max	Min	Max	Min			Max	Min	Max	Min						
314335	AUTOMATION TOOLS & SYSTEMS	AAS	DSC	3	-	4	1	8	4	3	30	70	100	40	25	10	25@	10	25	10	175

Total IKS Hrs for Sem. : 0 Hrs

Abbreviations: CL- Classroom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @\$ Internal Online Examination

Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks

5. 1 credit is equivalent to 30 Notional hrs.
 6. * Self learning hours shall not be reflected in the Time Table.
 7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's) aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	<p>TLO 1.1 Describe the need of PLC over the hardwired relay logic.</p> <p>TLO 1.2 Compare PLC with other dedicated controllers.</p> <p>TLO 1.3 Explain the function of different elements of PLC with the help of block diagram.</p> <p>TLO 1.4 Describe types of PLC and selection criteria for the given application.</p> <p>TLO 1.5 Explain concept of redundancy in PLC with suitable diagram.</p>	<p>Unit - I Fundamentals of PLC</p> <p>1.1 PLC in industrial automation: Benefits & limitations, comparison of PLC with Personal Computer (PC) and dedicated controllers like Microcontrollers and PID controllers</p> <p>1.2 Block diagram of PLC, building blocks of PLC: Power supply, CPU, memory organization, input-output modules (Discrete and analog), special I/O Modules</p> <p>1.3 Commonly used I/O devices used for PLC</p> <p>1.4 Types of PLC: Fixed, Modular</p> <p>1.5 Selection criteria of PLC based on different applications</p> <p>1.6 Concept of sinking and sourcing in PLC, Concept of redundancy in PLC</p>	<p>Lecture using Chalk-Board, Presentations, Video Demonstrations, Flipped Classroom</p>
2	<p>TLO 2.1 Describe different programming languages used to program PLC.</p> <p>TLO 2.2 Specify appropriate I/O addressing format for the given PLC.</p> <p>TLO 2.3 Explain use of different PLC programming instructions used to write a simple program for performing a given operation.</p> <p>TLO 2.4 Describe the PLC installation procedure.</p>	<p>Unit - II PLC Programming</p> <p>2.1 PLC programming languages: Functional Block Diagram (FBD), Instruction List, Structured text, Sequential Function Chart (SFC), Ladder Programming (Introduction only)</p> <p>2.2 Basics of ladder programming, PLC processor scan cycle, PLC I/O addressing in ladder logic</p> <p>2.3 PLC arithmetic functions (Add, subtract, multiply, divide instructions, increment and decrement instructions), PLC logical functions (NOT, AND, OR, XOR), PLC compare and data handling instruction</p> <p>2.4 Programming Timer: Addressing a timer block, status bits, ON delay, OFF delay and reset, retentive timer</p> <p>2.5 Programming Counter: Addressing a counter block, status bits, UP and DOWN counter, up-down counter</p> <p>2.6 PLC-PC interface, do's and don'ts in PLC installation</p>	<p>Lecture using Chalk-Board, Presentations, Video Demonstrations</p>
3	<p>TLO 3.1 Explain basics of Ladder programming for a given Boolean expression.</p> <p>TLO 3.2 Develop Ladder program for simple applications.</p> <p>TLO 3.3 Prepare Ladder program for a given industrial application.</p> <p>TLO 3.4 Describe regular PLC maintenance practices.</p> <p>TLO 3.5 Enlist steps to troubleshoot PLC for a specific</p>	<p>Unit - III PLC Applications and Maintenance</p> <p>3.1 Ladder programming for Seal in circuit, Boolean expression and logic gates</p> <p>3.2 Simple programming using ladder logic based on relay, timer, counter, logical, arithmetic, comparison, and data handling instructions</p> <p>3.3 PLC based applications: Motor sequence control, traffic light control, bottle filling plant, car parking, tank level control, conveyor system, stepper motor control</p> <p>3.4 Regular PLC maintenance practices</p>	<p>Lecture using Chalk-Board, Presentations, Video Demonstrations, Hands-on</p>

Sr.No	Theory Learning Outcomes (TLO's) aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
	application.	3.5 Standard steps for PLC troubleshooting	
4	TLO 4.1 Explain various benefits and applications of SCADA. TLO 4.2 Describe architecture of SCADA. TLO 4.3 Explain the need of HMI. TLO 4.4 Explain the major features of the given communication protocol used for SCADA.	Unit - IV Basics of SCADA and HMI 4.1 Supervisory Control and Data Acquisition (SCADA): Introduction, need, benefits and typical applications 4.2 SCADA architecture: Master Terminal Unit (MTU), Remote Terminal Unit (RTU), communication protocols, various editors of SCADA 4.3 Human Machine Interface (HMI): Introduction, need, benefits and typical applications 4.4 Industrial Networking: Network topologies, modes of network communication- Master slave, bus arbitration, token passing, random bus access (CSMA/CD), CS (Client-server) 4.5 RS232, RS422, RS485 standards for data communication 4.6 Industrial ethernet, concept of Fieldbus, MODBUS protocol, Highway Addressable Remote Transducer (HART) Protocol	Lecture using Chalk-Board, Presentations, Collaborative learning, Hands-on
5	TLO 5.1 Identify the steps in Interfacing of PLC and SCADA system. TLO 5.2 Describe the need and architecture of OPC. TLO 5.3 Describe the steps in creating simple SCADA screen for a given application. TLO 5.4 Identify the steps in integrating given HMI panel with given PLC. TLO 5.5 Enlist the steps to develop HMI screen for the given simple application.	Unit - V SCADA Application Development and HMI 5.1 Interfacing SCADA system with PLC: Typical connection diagram 5.2 Object linking and embedding for process control (OPC) - need, architecture 5.3 Developing SCADA screen for simple applications - conveyor system, car washing system, bottle filling and product Sorting 5.4 Steps for integrating PLC with HMI panel 5.5 Developing HMI screen for blinking, movement, filling and visibility of object	Lecture using Chalk-Board, Presentations, Video Demonstrations, Hands-on

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Inspect different controls available on front panel of PLC. LLO 1.2 Identify the function of each part of PLC.	1	*Identification of different parts of PLC front panel available in your laboratory	2	CO1
LLO 2.1 Segregate available devices into analog and discrete I/O devices. LLO 2.2 Segregate available devices into analog and discrete I/O devices.	2	Classification of various components available in laboratory into discrete I/O and analog I/O devices	2	CO1
LLO 3.1 Interface available discrete input devices to PLC. LLO 3.2 Interface available discrete output devices to PLC. LLO 3.3 Interface available discrete input	3	*Interfacing of discrete input and output devices to the PLC	2	CO1

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Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
devices to PLC. LLO 3.4 Interface available discrete output devices to PLC.				
LLO 4.1 Interface available analog input devices to PLC. LLO 4.2 Interface available analog output devices to PLC. LLO 4.3 Interface available analog input devices to PLC. LLO 4.4 Interface available analog output devices to PLC.	4	Interfacing of analog input and output devices to the PLC	2	CO1
LLO 5.1 Develop ladder program using relay instructions. LLO 5.2 Develop ladder program using relay instructions.	5	Development of ladder diagrams to design basic logic gates	2	CO2
LLO 6.1 Execute the use of timer instruction in PLC ladder programming. LLO 6.2 Execute the use of timer instruction in PLC ladder programming.	6	*Verification of ladder program for blinking of LEDs	2	CO2
LLO 7.1 Execute the use of counter instruction in PLC ladder programming. LLO 7.2 Execute the use of counter instruction in PLC ladder programming.	7	*Demonstration of ladder logic for pulse counting using push button/ limit switch/ proximity sensor	2	CO2
LLO 8.1 Demonstrate steps to install any PLC ladder programming software. LLO 8.2 Understand the features of ladder programming software.	8	Identification of different features of PLC software or Ladder programming simulation software	2	CO3
LLO 9.1 Develop ladder program using arithmetic instructions. LLO 9.2 Develop ladder program using comparison instructions. LLO 9.3 Develop ladder program using data handling instructions.	9	*Implementation of ladder program for the temperature measurement system of given liquid using RTD or Thermocouple	4	CO1 CO3
LLO 10.1 Develop ladder program for seal in circuit. LLO 10.2 Develop ladder program for motor sequence control.	10	Simulation of ladder diagram for motor sequence control	2	CO3
LLO 11.1 Develop ladder program for Traffic light control.	11	*Demonstration of traffic light control system using ladder diagram	2	CO3
LLO 12.1 Develop ladder program for bottle filling plant.	12	*Demonstration of a bottle filling plant using proximity sensor, solenoid valve, conveyer belt mechanism using PLC	2	CO1 CO3
LLO 13.1 Develop ladder program for Car parking system.	13	Simulation of a mall Entry-Exit car parking system using ladder diagram	2	CO3
LLO 14.1 Develop ladder program for water level indicator system.	14	Demonstration of a basement and overhead water tank level indication system using PLC	2	CO3
LLO 15.1 Develop ladder program for Stepper motor control.	15	*Execution of stepper motor rotation in clockwise and anti-clockwise direction using PLC	2	CO3
LLO 16.1 Configure and perform hands-on practice to identify various features of any available SCADA software in the laboratory.	16	*Identification of various features of given SCADA software	2	CO4

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Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 17.1 Identify Different objects configuration (buttons, lamps, motors, conveyor) and dynamic properties(blinking, filling, movement) in SCADA software. LLO 17.2 Configure and perform hands-on practice to identify various features of any available SCADA software in the laboratory.	17	*Identification of various features of given SCADA software	2	CO4
LLO 18.1 Identify different network cables (Fiber optics, coaxial, twisted) and their accessories used in SCADA communication.	18	Identification of various available network cables used in SCADA	2	CO4
LLO 19.1 Identify different network communication buses (Modbus, Profibus) used in SCADA.	19	Identification of different network communication buses used in SCADA	2	CO4
LLO 20.1 Configure available HMI panel with software and integrate it with a given PLC.	20	*Identification of various features of OPC DA server software	2	CO5
LLO 21.1 Configure available HMI panel with software and integrate it with a given PLC.	21	*Identification of various features of OPC DA server software	2	CO5
LLO 22.1 Develop SCADA graphic screen and integrate it with PLC to perform seal in logic.	22	*Development of the interconnection between PLC and SCADA software using OPC	4	CO5
LLO 23.1 Develop SCADA graphic screen and integrate it with PLC to perform conveyor control.	23	*Development of SCADA graphic screen and interfacing it with PLC to perform seal-in-logic	2	CO5
LLO 24.1 Develop SCADA graphic screen and integrate it with PLC to perform car washing systems. LLO 24.2 Develop SCADA graphic screen and integrate it with PLC to perform conveyor control.	24	*Development of SCADA graphic screen and interfacing it with PLC to perform Conveyor control operation	2	CO5
LLO 25.1 Develop SCADA graphic screen and integrate it with PLC to perform product sorting.	25	Development of SCADA graphic screen and interfacing it with PLC to perform car washing system	2	CO5
LLO 26.1 Develop SCADA graphic screen and integrate it with PLC to perform bottle filling operation. LLO 26.2 Develop SCADA graphic screen and integrate it with PLC to perform bottle filling operation.	26	Development of SCADA graphic screen and interfacing it with PLC to perform bottle filling operation	2	CO5
LLO 27.1 Configure available HMI Panel with software and integrate it with a given PLC. LLO 27.2 Develop SCADA graphic screen and integrate it with PLC to perform object sorting operation.	27	Development of SCADA graphic screen and interfacing it with PLC to perform object sorting operation	2	CO5
LLO 28.1 Develop HMI graphic screen for blinking, movement and visibility of an object. LLO 28.2 Develop HMI graphic screen for blinking, movement and visibility of an object.	28	*Development of HMI graphic screens for different properties of given objects	2	CO5

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Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
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Note : Out of above suggestive LLOs -

- '* Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Micro project

- Automatic mixing system: Implement Automatic product mixing control system using PLC.
- Traffic light control: Prepare PLC based simple traffic light control system.
- Elevator control: Prepare a 4 floor elevator control system using PLC.
- Automatic Street light controller: Prepare a SCADA based system to control the street lights as per the intensity of natural light.
- Coffee vending machine: Develop Plc based coffee vending machine.
- Level control system: Prepare water tank discrete level control system using PLC.
- Home automation: Implement a versatile automation system for home that can automate any three home appliances using SCADA.
- Railway gate automation: Prepare a SCADA based system to control the railway gate automatically.
- Automatic agricultural irrigation system: Prepare a SCADA based to control drip irrigation.
- Sequential control of Motors: Develop a HMI control system for operating different motors sequentially.
- Product counting on conveyor: Make a HMI application to count product passing on conveyor in a specific time.
- Color sensing and sorting of objects: Develop a HMI screen for sorting of different products based on color.

Student activity

- Make a Report on general maintenance and troubleshooting methods of PLC.
- Make a report on market survey of different types of PLC software.
- Make a report on market survey of different types of HMI panels and software.
- Make a report on market survey of different types of SCADA software.
- Visit any virtual lab to perform an activity and prepare a report on it.

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Trainer setup for PLC - stepper motor interface, Conveyer belt assembly	10,12,15

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Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
2	IEC Standard compatible latest version of SCADA software from any reputed manufacturer like - Ellipse/ Citect/ wonderware - intouch/ Json/ Wincc/ Cimplicity etc.	16,17,21,22,23,24,25,26
3	Trainer set up for Coaxial cable, UTP and STP cables, Fiber optics cable with associated connection accessories	18
4	Trainer setup for Network communication Buses such as Modbus / Profibus etc.	19
5	Input and output devices for PLC: lamps, DC motors, Proximity sensors, Temperature Sensors, Limit switches, Push buttons, RTD/ Thermocouple	2,3,4,7,9,11,12
6	Open Source OPC DA server softwares like - Kepserver OPC / MXOPC / Matrikon OPC	20,21,26
7	Min 7' inch HMI Panel with required software -Siemens, Delta, Weintek, Schneider etc.	27,28
8	IEC 1131-3 compatible PLC with programming Software and interfacing Hardware - (Micro and Modular PLC with analog and digital I/Os) along with user manual	8,9,10,11,12,13,14,15,1,2,3,4,5,6,7
9	Computer System: OS with windows 10 or higher, minimum of 8 GB RAM, Minimum of Intel core i3 or equivalent	All

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Fundamentals of PLC	CO1	8	4	4	2	10
2	II	PLC Programming	CO2	10	6	6	6	18
3	III	PLC Applications and Maintenance	CO3	10	2	4	8	14
4	IV	Basics of SCADA and HMI	CO4	9	4	6	8	18
5	V	SCADA Application Development and HMI	CO5	8	2	4	4	10
Grand Total				45	18	24	28	70

X. ASSESSMENT METHODOLOGIES/TOOLS**Formative assessment (Assessment for Learning)**

- Two offline unit tests are of 30 marks and average of two unit test marks will be consider for out of 30 marks. For formative assessment of laboratory learning 25 marks. Each practical will be assessed considering 60% weightage to process, 40% weightage to product.

Summative Assessment (Assessment of Learning)

- End semester assessment is of 70 marks. End semester summative assessment is of 25 marks for laboratory learning.

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline	PO-2 Problem Analysis	PO-3 Design/ Development	PO-4 Engineering Tools	PO-5 Engineering Practices for	PO-6 Project Management	PO-7 Life Long	PSO-1	PSO-2	PSO-3

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	Specific Knowledge		of Solutions		Society, Sustainability and Environment		Learning			
CO1	3	2	-	2	-	-	2			
CO2	3	3	2	3	-	-	2			
CO3	3	3	3	3	2	1	2			
CO4	3	2	1	2	-	-	2			
CO5	3	3	3	3	2	1	2			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Dunning, Garry	Introduction to Programmable Logic Controller	Thomson/Delmar Learning, 2005 ISBN: 978-1401884260
2	Petruzella, F.D.	Programmable Logic Controller (Fourth Edition)	Tata-McGraw Hill India, 2010 ISBN: 978-0071067386
3	Hackworth, John; Hackworth, Federic	Programmable Logic Controller	Prentice Hall, 2003 ISBN: 978-0130607188
4	Boyar, S. A.	Supervisory Control and Data Acquisition	ISA publication (4th edition), ISBN: 978-1936007097
5	Bailey, David; Wright, Edwin	Practical SCADA for Industry	Newnes (an imprint of elsevier), 2003 ISBN: 0750658053
6	Manoj, K.S.	Industrial Automation with SCADA Concept, Communication and Security	Notion Press, eISBN: 9781684668298

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.youtube.com/watch?v=MS3qJq2jvu0	This NPTEL lecture discuss about basics of program logic controllers. Various programming techniques and terms used in PLC are discussed in detail.
2	https://instrumentationtools.com/free-allen-bradley-plc-ladder-logic-training-course/	Allen Bradley PLC Ladder Logic Training Course.
3	https://www.youtube.com/watch?v=E2WNPXJf-Kw	PLC Introduction. PLC Basics, Components of PLC, Modular PLC Modules, Input Output.
4	https://www.matrikonopc.com/opc-server/opc-data-access-versions.aspx	OPC Data Access (OPC DA) Versions & Compatibility.
5	https://github.com/riclolsen/json-scada/releases/download/V0.31-alpha/json-scada_setup_v.0.31.exe	An open source SCADA software.
6	https://www.ptc.com/en/products/kepware/kepserverex/demo-download	Keptserver OPC free Demo software.
7	https://citectscada.software.informer.com/download/#download	Student version of Citect SCADA software.

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Sr.No	Link / Portal	Description
8	https://www.weintek.com/globalw/Software/EasyBuilderPro.aspx	An open source HMI software/ Simulator.
9	https://ial-coep.vlabs.ac.in/	Virtual Laboratory on automation.
Note : <ul style="list-style-type: none">• Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students		

MSBTE Approval Dt. 21/11/2024**Semester - 4, K Scheme**