**INDUSTRIAL AUTOMATION** **Course Code : 316329**

**Programme Name/s** : **Electrical Engineering/ Electrical Power System**
**Programme Code** : **EE/ EP**
**Semester** : **Sixth**
**Course Title** : **INDUSTRIAL AUTOMATION**
**Course Code** : **316329**

## I. RATIONALE

Every industry is moving towards automation. Industries rely heavily on automation for economic feasibility, mass production and more quality. This course will enable the diploma students to apply the basics of automation and control the process/production using Program Logic Controller(PLC), Supervisory Control and Data acquisition (SCADA) and Distributed Control System (DCS) in automation. This course will provide an opportunity to learn industrial automation techniques.

## II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the student to attain the following industry-identified competency through various teaching-learning experiences ;

- **Automate production lines using PLC, SCADA and DCS**

## III. COURSE LEVEL LEARNING OUTCOMES (COS)

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

- CO1 - Develop control and power circuits for the given application
- CO2 - Apply the fundamentals of PLC for effective operation
- CO3 - Apply the basics of PLC programming for a given application
- CO4 - Test ladder logic programs for given industrial applications
- CO5 - Familiarize the SCADA and DCS architecture for process contol and data acquisition from the field.

## IV. TEACHING-LEARNING & ASSESSMENT SCHEME

| Course Code | Course Title | Abbr | Course Category/s | Learning Scheme | | | | | Credits | Assessment Scheme | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Actual Contact Hrs./Week | | | SLH | NLH | | Paper Duration | Theory | | | | Based on LL & TL | | | | Based on SL | | Total Marks |
| | | | | | | | | | | | | | | | Practical | | | | | | |
| | | | | CL | TL | LL | | | | | FA-TH | SA-TH | Total | | FA-PR | | SA-PR | | SLA | | |
| | | | | | | | | | | | Max | Max | Max | Min | Max | Min | Max | Min | Max | Min | |
| 316329 | INDUSTRIAL AUTOMATION | EIA | DSE | 3 | - | 2 | 1 | 6 | 3 | 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 | TLO 1.1 Interpret the device and its function based on its symbolical representation<br>TLO 1.2 Describe the working of a given Input/output device used in Industrial Control Circuits<br>TLO 1.3 Differentiate the operation of the control and power circuit for the given motor control circuit<br>TLO 1.4 Develop control and power circuits for the given process control application(s). | **Unit - I Industrial Control Circuits**<br>1.1 Need and benefit of automation, Different input devices such as push button, selector switch, limit switch, proximity switch and pressure switch.<br>1.2 Different output devices such as relay, contactor, solenoid valve, solid state relay (SSR)<br>1.3 Different symbols used in industrial control circuits. Concept of control and power circuit diagram.<br>1.4 Commonly used motor control circuits - a) DOL starting b) Star-delta starter c) FWD-STOP-REV control and random reversing of induction motor. d) Soft Starters<br>1.5 Typical control and power circuit diagrams of hoist control, conveyer control (Interlocking of minimum three conveyors) | Lecture Using Chalk-Board<br>Presentations<br>Case Study<br>Flipped Classroom<br>Model Demonstration<br>Video Demonstrations<br>Demonstration<br>Hands-on<br>Site/Industry Visit |

| 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. |
|---|---|---|---|
| 2 | TLO 2.1 Describe architecture of PLC with a neat block diagram along with functions of each part<br>TLO 2.2 Describe CPU functioning and memory organization of PLC<br>TLO 2.3 Describe Redundancy concept in PLC<br>TLO 2.4 State specifications of given PLC<br>TLO 2.5 Enlist different brand and model of PLC's available in the market<br>TLO 2.6 Explain the need and significance of International standard for PLC IEC 61131-1, IEC 61131-2, IEC 61131-3 | **Unit - II PLC Fundamentals**<br>2.1 Architecture of PLC : Block Diagram and function of each block<br>2.2 CPU Working : PLC Scan Cycle, Speed of execution, working modes of CPU (Programming, RUN,REM Modes)<br>2.3 Redundancy and memory organization of PLC<br>2.4 Classification of PLCs: According to structure, Size. Advantages of PLC based automation over relay based automation, Specifications of PLC, Different PLCs available in market, PLC comparison with PC<br>2.5 Digital and Analog IO modules of PLC, Block diagram and specification, Function of communication module<br>2.6 Micro PLC : Introduction, comparison with PLC, Applications<br>2.7 International standard for PLC IEC 61131-1, IEC 61131-2, IEC 61131-3 | Lecture Using Chalk-Board<br>Presentations<br>Case Study<br>Flipped Classroom<br>Model Demonstration<br>Video Demonstrations<br>Demonstration<br>Hands-on<br>Site/Industry Visit |
| 3 | TLO 3.1 State features of PLC programming languages<br>TLO 3.2 Develop Ladder diagram for different logic gates<br>TLO 3.3 Develop the PLC ladder programs for the given situations.<br>TLO 3.4 Describe program scan process for the given type of PLC<br>TLO 3.5 Describe various types of PLC instructions | **Unit - III Basics of PLC Programming**<br>3.1 Binary system, bit, byte, word, logic gates, PLC Programming languages : Ladder Logic ,Sequential Function Charts (SFC), Function Block Diagram (FBD), Structured Text (ST), Instruction List(IL) - (Only Introduction , Advantages and Disadvantages)<br>3.2 Programming PLC using ladder diagram, Components of ladder diagram, Program scan process applied to single rung.<br>3.3 Ladder diagram for different logic gates : AND, OR, NOR and XOR<br>3.4 PLC Instructions : (i) Bit type instructions- XIC, XIO, OTE, OTL, OUT, OSR (ii) Logical instructions- OR, AND, NOT, XOR (iii) Comparison instructions- EQU, NEQ, LES, LEQ, GRT, GERQ, LIM (iv) Timer instructions- TON, TOFF, RTO (v) Counter instructions- CTU, CTD (vi) Scaling instructions- SCP | Lecture Using Chalk-Board<br>Presentations<br>Case Study<br>Flipped Classroom<br>Model Demonstration<br>Video Demonstrations<br>Demonstration<br>Hands-on<br>Site/Industry Visit |
| 4 | TLO 4.1 Explain the function of seal in circuit in ladder logic<br>TLO 4.2 Explain the use of Latch relay in PLC programming<br>TLO 4.3 Develop PLC ladder logic for given Industrial application | **Unit - IV Advanced PLC Programming**<br>4.1 Seal in circuit<br>4.2 Latching Relay using PLC<br>4.3 System Design, I/O listing, Wiring Diagram and Ladder Logic for Industrial Applications : DOL starter with OLR, water level controller, Forward reverse control of 3-phase IM, Temperature control (ON/OFF), Stepper motor control , Bottle filling system, Traffic Light Control | Lecture Using Chalk-Board<br>Presentations<br>Case Study<br>Flipped Classroom<br>Model Demonstration<br>Video Demonstrations<br>Demonstration<br>Hands-on<br>Site/Industry Visit |

| 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. |
|---|---|---|---|
| 5 | TLO 5.1 Explain SCADA system architecture used in Industrial Automation with the help of Block diagram<br>TLO 5.2 Explain DCS system architecture used in Industrial Automation with the help of Block diagram<br>TLO 5.3 Compare PLC, SCADA and DCS | **Unit - V SCADA and DCS**<br>5.1 Supervisory Control and Data acquisition (SCADA): Basic function, generalized block diagram, function of each block, interfacing SCADA with PLC, simple mimic diagrams, applications of SCADA<br>5.2 Distributed Control System: Basic function, generalized block diagram, function of each block, applications of DCS<br>5.3 Comparison of PLC, SCADA and DCS | Lecture Using Chalk-Board<br>Presentations<br>Case Study<br>Flipped Classroom<br>Model Demonstration<br>Video Demonstrations<br>Demonstration<br>Hands-on<br>Site/Industry Visit |

## 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 Interpret different symbols used in a given industrial control diagram | 1 | * Identification of symbols used in industrial control diagrams. | 2 | CO1 |
| LLO 2.1 Simulate a simple seal-in circuit using PLC simulator.<br>LLO 2.2 Addressing of Input and output devices | 2 | Simulation of a simple seal-in circuit using PLC simulator. | 2 | CO4 |
| LLO 3.1 Connect PLC to PC<br>LLO 3.2 Addressing properly different input and output devices<br>LLO 3.3 Test the ladder logic programs for basic logic gates operations ( AND, OR, XOR, NOR) | 3 | Testing of the ladder logic program for basic logic gates operations | 2 | CO2 |
| LLO 4.1 Draw logic diagram to create 10 second delay after a push button press using timer instruction block<br>LLO 4.2 Address properly the input, output devices and timer instruction/block<br>LLO 4.3 Test the ladder logic | 4 | PLC program to create a delay using a given timer function | 2 | CO3 |
| LLO 5.1 Draw ladder logic diagram for connecting a star delta starter to a 3 phase induction motor<br>LLO 5.2 Address properly the input output devices<br>LLO 5.3 Test the ladder logic program | 5 | Ladder logic program for STAR-DELTA staring of a 3ph. Induction motor | 2 | CO3 |
| LLO 6.1 Draw ladder logic diagram for controlling the direction of rotation for a 3 phase induction motor<br>LLO 6.2 Address properly the input output devices<br>LLO 6.3 Test the ladder logic program<br>LLO 6.4 Interface the 3 phase induction motor to the PLC with the help of Motor module | 6 | * Reversal of Direction of rotation of 3ph. Induction motor with the help of PLC. | 2 | CO4 |

| Practical / Tutorial / Laboratory Learning Outcome (LLO) | Sr No | Laboratory Experiment / Practical Titles / Tutorial Titles | Number of hrs. | Relevant COs |
|---|---|---|---|---|
| LLO 7.1 Draw ladder logic diagram for controlling the direction of rotation for a steeper motor<br>LLO 7.2 Address properly the input output devices<br>LLO 7.3 Test the ladder logic program<br>LLO 7.4 Interface the steeper motor to the PLC with the help of Motor module | 7 | Control of the direction of rotation of a given stepper motor. | 2 | CO4 |
| LLO 8.1 Draw ladder logic diagram for controlling the temperature of given process<br>LLO 8.2 Address properly the input devices (Temperature Sensor)<br>LLO 8.3 Test the ladder logic program<br>LLO 8.4 Interface the Temperature sensor to the PLC | 8 | * Control of Temperature with the help of PLC | 2 | CO4 |
| LLO 9.1 Draw ladder logic diagram for controlling the traffic lights.<br>LLO 9.2 Address properly the input and ouput devices<br>LLO 9.3 Test the ladder logic program | 9 | * Simulating traffic light control with the help of PLC | 2 | CO4 |
| LLO 10.1 Draw ladder logic diagram for blinking of light.<br>LLO 10.2 Address properly the input and output devices<br>LLO 10.3 Test the ladder logic program | 10 | Ladder logic for blinking of a lamp | 2 | CO3 |
| LLO 11.1 Draw ladder logic diagram to simulate given gate<br>LLO 11.2 Address properly the input and output devices<br>LLO 11.3 Test the ladder logic program | 11 | *Implementation of Logic gates using PLC using Virtual Lab | 2 | CO3 |
| LLO 12.1 Draw ladder logic diagram for bottle filling plant.<br>LLO 12.2 Address properly the input and output devices<br>LLO 12.3 Test the ladder logic program<br>LLO 12.4 Interface the input and output devices to the PLC | 12 | * Ladder logic for automatic bottle filling plant using virtual lab | 2 | CO4 |
| LLO 13.1 Draw ladder logic diagram for automatic water tank level control<br>LLO 13.2 Address properly the input and output devices<br>LLO 13.3 Test the ladder logic program<br>LLO 13.4 Interface the input and output devices to the PLC | 13 | * Automatic water tank level control system using PLC | 2 | CO4 |
| LLO 14.1 Identify various features and properties of SCADA system | 14 | Identification of various components in library/ Wizard and properties of SCADA software | 2 | CO5 |

| Practical / Tutorial / Laboratory Learning Outcome (LLO) | Sr No | Laboratory Experiment / Practical Titles / Tutorial Titles | Number of hrs. | Relevant COs |
|---|---|---|---|---|
| LLO 15.1 Identify hardware and software platform for DCS using virtual lab | 15 | * Identification of hardware and software platform for DCS using virtual lab | 2 | CO5 |

**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**

- Display temperature and humidity at the entrance of the institute and institute campus. Compare the reading and submit a report
- Prepare a project of Automatic bottle filling plant on conveyor belt using SCADA software
- Prepare a project indicating historical/real-time trend for an event using SCADA software
- Design a small automation model for automatic ON/OFF control of a light in a room according to occupancy in the room
- Automatic railway gate controlling system
- Demonstration of five axes rotation of Robotic Arm
- Control of servo-motor and stepper motor by using Raspberry Pi 4.0
- Report on PLC-based Speed Control of Electric Vehicle
- Operate Robot-Based Welding Automation

**Market Survey**

- Make a survey of commercially available PLCs in the market.
- Make a survey of industrial control components based on their ratings.

**Industry Visit**

- Visit any manufacturing / process plant having PLC automation
- Visit any manufacturing / process plant having SCADA and / or DCS
- Visit any manufacturing/process plant having a Robotic automation

**Assignment**

- Give the selection criteria of I/O modules in automation system
- Enlist International manufacturers of PLC/SCADA/DCS/HMI
- Write the report on the use of DCS in oil and gas refineries
- Write the report on DCS used in water treatment plants

**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 | Push buttons, indicating lamps , float switch, Selector Switch ,Limit switch, proximity switch ( Capacitive, Inductive , Magnetic ), Pressure switch (Danfoss KP36 or equivalent ) - Each 4 Nos. | 1 |
| 2 | Sensors : Proximity - Inductive, LVDT, Capacitive, Ultrasonic, Optical, Temperature, Flow, pressure, piezoelectric, photoelectric - Each 4 Nos. | 1 |
| 3 | DIN rail mounted AC contactor, 3 power poles with 1 NO and 1 NC contact | 1 |
| 4 | COEP Technological University's Virtual Lab (Industrial Automation and Programmable Logic Controller Laboratories under Electrical Department.) | 11,12,15 |
| 5 | Float switch , solenoid valve | 13 |
| 6 | Any SCADA software | 14 |
| 7 | PLC with min 8 I/Os and HMI and its simulation/programming software.(1 No.) | 2,3,4,5,6,7,8,9,10,13 |
| 8 | Induction motor drive model | 6 |
| 9 | Stepper motor drive module. | 7 |

## 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 | Industrial Control Circuits | CO1 | 7 | 0 | 2 | 4 | 6 |
| 2 | II | PLC Fundamentals | CO2 | 10 | 2 | 8 | 8 | 18 |
| 3 | III | Basics of PLC Programming | CO3 | 10 | 2 | 8 | 8 | 18 |
| 4 | IV | Advanced PLC Programming | CO4 | 10 | 2 | 8 | 8 | 18 |
| 5 | V | SCADA and DCS | CO5 | 8 | 2 | 0 | 8 | 10 |
| **Grand Total** | | | | **45** | **8** | **26** | **36** | **70** |

## X. ASSESSMENT METHODOLOGIES/TOOLS

**Formative assessment (Assessment for Learning)**

- Two unit tests of 30 marks will be conducted and average of marks obtained in these two unit tests will be considered. Each practical will be assessed for 25 marks and average of all marks obtained will be considered.

**Summative Assessment (Assessment of Learning)**

- End semester assessment of 70 marks for classroom learning. End semester assessment 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 Specific Knowledge | PO-2 Problem Analysis | PO-3 Design/ Development of Solutions | PO-4 Engineering Tools | PO-5 Engineering Practices for Society, Sustainability and Environment | PO-6 Project Management | PO-7 Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| CO1 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | | | |
| CO2 | 2 | 2 | 2 | 2 | 2 | - | 2 | | | |
| CO3 | 3 | 2 | 2 | 2 | 2 | - | 2 | | | |
| CO4 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | | | |
| CO5 | 2 | 2 | 3 | 3 | 2 | 2 | 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 | Bhattacharya, S.K.; Singh, B. | Control of Machines | New Age International Publishers, New Delhi, 2006, ISBN: 978122418187 |
| 2 | Eswar, U.S. | Handbook of Electrical Motor Control Systems | McGraw Hill Education, New Delhi, 2013, ISBN : 978-0074601112 |
| 3 | Madhuchhanda Mitra , Samarjt Sengupta | Programmable Logic Controllers and Industrial Automation: An Introduction | Penram International Publication , New Delhi,2017, ISBN : 978-8187972631 |
| 4 | Stuart A. Boyer | SCADA: Supervisory Control and Data Acquisition | ISA, 1999, ISBN : 1556176600, 9781556176609 |
| 5 | Garry Dunning | Introduction to Programmable logic Controller | Delmar Cengage learning ISBN-13978-1401884260 Edition 3 Publication Date-16 December 2005 |
| 6 | Boyar S.A | Supervisory control and data acquisition | ISA Publication, USA ISBN: 978-193600709 |
| 7 | Bhatkar Vijay P. | Distributed computer control system in industrial automation | Routledge 2017 : ISBN 9781351454698 |
| 8 | Frank D. Petruzella | Programmable Logic Controllers | McGraw Hill ISBN - 13978-9353167271 |

## XIII . LEARNING WEBSITES & PORTALS

| Sr.No | Link / Portal | Description |
|---|---|---|
| 1 | https://portal.coepvlab.ac.in/vlab/auth/home?dept=3&lab=4 | Virtual Lab for PLC : from COEP Technological University , Pune |
| 2 | https://portal.coepvlab.ac.in/vlab/auth/home?dept=3&lab=2 | Virtual Lab for Industrial Automation : from COEP Technological University , Pune |
| 3 | https://www.youtube.com/watch?v=PLYosK87D8E | PLC basics |
| 4 | https://www.youtube.com/watch?v=Hci-eW5IihM | Basics of PLC Ladder Diagram |
| 5 | https://www.youtube.com/watch?v=1pRv-p_HbRk | Controlling Water Level in the PLC Ladder Logic Program |

| Sr.No | Link / Portal | Description |
|---|---|---|
| 6 | https://www.youtube.com/watch?v=3WATUnwCwRA | Mastering PLC Programming: Traffic Light Control |
| 7 | https://www.youtube.com/watch?v=8UQOhGp8gqY | Basic PLC bottle filling process |
| 8 | https://youtu.be/86uY3TQq2Yk?si=tpM6Rh4CFOmQONJY | Introduction to SCADA Systems \| What is SCADA? |
| 9 | https://youtu.be/DlFOIoFjJwc?si=Zlq8BIzSzxW36kOY | DCS vs PLC \| Understanding the Differences and Applications |

**Note :**

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students