**Program Name** : **Diploma in Automation and Robotics**
**Program Code** : **AO**
**Semester** : **Sixth**
**Course Title** : **Distributed Control Systems and HMI**
**Course Code** : **22680**

## 1. RATIONALE

Nowadays, manufacturing industries are being automated by advanced automation devices and systems for measurement and control of various field parameters. In today's competitive production environment, automation industries demand a totally integrated control and optimization solution that can increase productivity, reliability and quality while minimizing cost. Distributed control system (DCS) is designed to meet these customer's needs. HMI is another automation device which acts as a window to the process plant. This course enables students to maintain DCS and HMI systems.

## 2. COMPETENCY

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

- **To maintain Distributed Control System and operate HMI Panels.**

## 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:

CO.a. Describe the operation of a typical DCS system.
CO.b. Maintain the hardware of a given DCS system.
CO.c. Configure software for a given DCS system.
CO.d. Describe the operation of a typical HMI panel
CO.e. Configure HMI software for basic 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 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 center of this map.

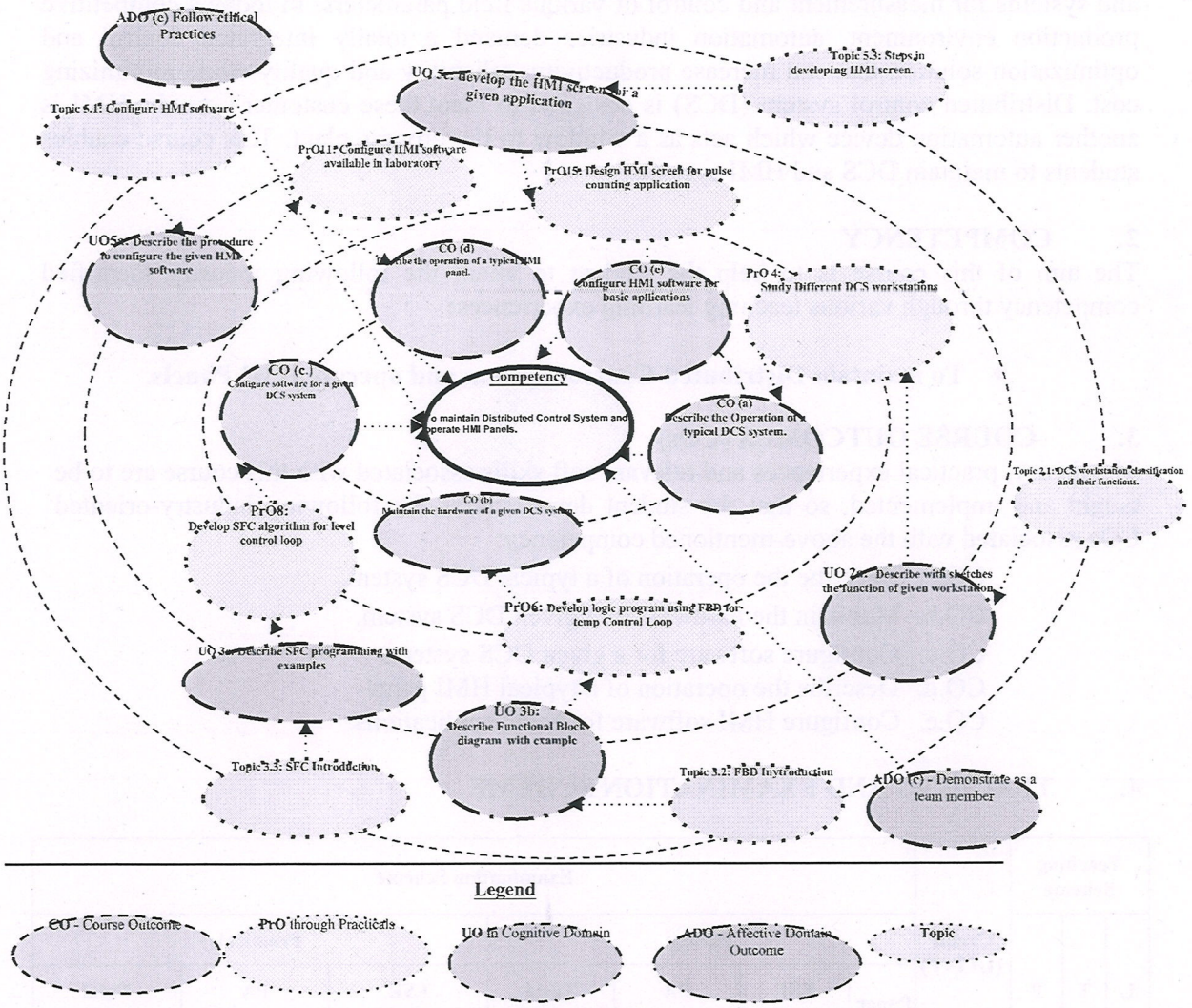


**Figure 1 - Course Map**

## 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.

| Sr. No. | Practical Outcomes (PrOs) | Unit No. | Approx. Hrs. Required |
|---|---|---|---|
| 1 | Prepare configuration and wiring diagram for DCS system available in laboratory | I | 2* |
| 2 | Interface the given I/O devices with relevant I/O module for the given system | I | 2* |
| 3 | Interface the communication module with relevant communication protocol for the given DCS system | I | 2 |
| 4 | Study Different DCS workstations. | II | 2* |
| 5 | Develop logic program using FBD for level control loop | III | 2* |
| 6 | Develop logic program using FBD for Temperature control loop | III | 2* |
| 7 | Develop logic program using FBD for pressure control loop | III | 2 |
| 8 | Develop SFC algorithm for level control loop | III | 2* |
| 9 | Develop SFC algorithm for temperature control loop | III | 2* |
| 10 | Develop SFC algorithm for pressure control loop | III | 2 |
| 11 | Study of available HMI panel hardware. | IV | 2* |
| 12 | Configure HMI software available in the laboratory. | V | 2* |
| 13 | Interface the HMI with available PLC in the laboratory. | V | 2* |
| 14 | Design HMI screen for Blinking, movement, filling, visibility. | V | 2* |
| 15 | Design HMI screen for Automatic opening/ closing of doors. | V | 2* |
| 16 | Design HMI screen for Pulse counting applications. | V | 2* |
| | | **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 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 % |
|---|---|---|
| 1. | Preparation of experimental setup. | 20 |

| | | |
|---|---|---|
| | 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 | PrO'S. No. |
|---|---|---|
| 1 | Computer System, operating system windows 10 or higher memory: Minimum 8 GB RAM | 5-16 |
| 2 | Standard DCS system of reputed Brand (such as Delta V, SIMATIC. PCS7) with analog and digital module, power supply module, communication module, controller module with compatible software | 1- 4 |
| 3 | Level trainer kit, temperature trainer kit, pressure measurement kit, flow trainer kit | 5-10 |
| 4 | HMI Panel with appropriate software. | 11-16 |

## 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 Introduction to DCS system** | 1a. Explain the evolution of the DCS system.<br>1b. Explain with sketches the hierarchical control.in automation.<br>1c. Describe the basic building block of a given DCS system.<br>1d. Classify the given I/P and O/P module.<br>1e. Explain with sketches the working of a given DCS module. | 1.1 Evolution of DCS system - Direct digital control, Centralized computer system, Distributed control system.<br>1.2 Hierarchical control in automation.<br>1.3 Basic building block of DCS System Architecture and its operation.<br>1.4 Input and Output module: Local, Remote, Rack mounted<br>1.5 Controller module, Power supply module, Communication module. |
| **Unit– II DCS Workstation and Maintenance** | 2a. Describe with sketches the function of a given workstation and data highway and local I/O bus.<br>2b. Explain Redundancy in DCS.<br>2c. Describe the Routine maintenance of the DCS system.<br>2d. Explain maintenance procedure for DCS system. | 2.1 DCS workstation classification and their functions: Operator, Engineering, Diskless, Intelligent, Historian, Application, Portable.<br>2.2 Data Highway and Local IO buses<br>2.3 Redundancy in DCS<br>2.4 DCS system Maintenance Consideration- Reliability, Availability, Single loop Integrity, backup system and fault tolerance system<br>2.5 Typical DCS maintenance procedure. |
| **Unit– III DCS Software configuration and displays** | 3a. Select the relevant DCS for a given application.<br>3b. Describe Functional block diagram with example<br>3c. Describe Sequential function chart programming with an example.<br>3d.Explain features of a given DCS display.<br>3e.Describe alarms, logs and reports in DCS. | 3.1 DCS brands: Delta V, Simatic PCS 7- Architecture, features and specifications.<br>3.2 Functional block diagram (FBD) programming: Introduction, Function blocks for standard logical functions, timer, counter, comparison blocks, FBD examples for simple application - on-off controller, single loop control system.<br>3.3 Sequential function chart programming (SFC): Introduction, branching in SFC - parallel, selective, convergence, divergence. SFC example for simple applications - on-off controller, |

| | | |
|---|---|---|
| | | single loop control system.<br>3.4 Standard DCS displays: Overview display, group display, graphic display, trend display, loop display.<br>3.5 DCS Alarms, logs and reports. |
| **Unit– IV Human Machine Interface** | 4a. Explain the evolution of HMI.<br>4b. Describe the need and benefits of an industrial HMI.<br>4c. Describe the features and characteristics of a given HMI software.<br>4d. List the Selection criteria for HMI. | 4.1 Introduction to HMI, History of HMI.<br>4.2 Need and benefits of industrial HMI.<br>4.3 Commercial HMI software package: Vijeo designer, wincc (Features and characteristics only)<br>4.4 Criteria for selection of good HMI. |
| **Unit-V HMI design and applications** | 5a. Describe the procedure to configure the given HMI software.<br>5b. Explain HMI integration with PLC.<br>5c. Develop the HMI screen for a given application.<br>5d. Enlist the applications of HMI in automation industries. | 5.1 Configuring HMI software: creating graphics, animation, trends, alarm and tag database.<br>5.2 HMI integration with PLC and hardware.<br>5.3 Steps in developing HMI screen for:<br>Blinking, movement, filling, visibility of object.<br>Automatic opening/ closing of doors.<br>Pulse counting applications<br>Sequential operation of motors.<br>5.4 HMI applications in automation industries. |

***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 |
| 1 | Introduction to DCS system | 08 | 6 | 6 | 2 | 14 |
| 2 | DCS Workstation and Maintenance | 10 | 6 | 8 | 2 | 16 |
| 3 | DCS Software configuration and displays | 14 | 4 | 6 | 8 | 18 |
| 4 | Human Machine Interface | 06 | 4 | 2 | 2 | 08 |
| 5 | HMI design and applications | 10 | 4 | 4 | 6 | 14 |

| | | | | | |
|---|---|---|---|---|---|
| Total | 48 | 24 | 26 | 20 | 70 |

## 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. Compare various brands of DCS on various parameter
b. Read an operating manual of DCS and prepare report
c. Visit nearby industry and prepare the list of various I/O
d. Prepare PowerPoint presentation on maintenance of DCS system
e. Presentation on HMI Application

## 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 different books and websites to have a deeper understanding of the subject.
h. Observe continuously and monitor the performance of students in the Lab
i. Use proper equivalent analogy to explain different concepts.
j. Use Flash/Animations to explain various Robotic actions

## 12. SUGGESTED MICRO-PROJECTS

***Only one micro-project*** is planned to be undertaken by a student 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. Develop SFC for bottle filling plan
b. Develop SFC for traffic light controller
c. Develop SFC for any batch process
d. HMI based simple applications such as ON/OF, Level measurement, Temperature measurement, Flow measurement.

## 13. SUGGESTED LEARNING RESOURCES

| S. No. | Title of Book | Author | Publication |
|---|---|---|---|
| 1 | Instrument Engineer handbook, Volume 3 | BELA G LIPTAK, HALIT EREN | CRC Press ,2016; ISBN 9781439863435 |
| 2 | Industrial process automation system: Design and Implementation | Mehta, B.R Reddy.Y. Jaganmohan | Butterworth - Heinemann,2014: ISBN 9780128010983 |
| 3 | Distributed computer control system in Industrial Automation | Bhatkar, Vijay P. | Routledge,2017, ISBN9781351454698 |
| 4 | Programming PLC And HMI for Sensors Automation | Ulysses Arnwine | ISBN-13, 979-8727288801 |

## 14. SUGGESTED SOFTWARE / LEARNING WEBSITES:

a. http://www.instrumenationcontrol.com
b. http://ial-coep.vlabs.ac.in/
c. http://coep.vlab.co.in/index.php?sub=33&brch=93&sim=425&cnt=571
d. http://www2.emersonprocess.com/en-US/documentation/Pages/DocSearch.aspx
e. www.yokogawa.com
f. https://www.inductiveautomation.com/resources/article/what-is-hmi#:~:text=HMI%20Defined,context%20of%20an%20industrial%20process.