GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Diploma Engineering

Level: Diploma

Branch: Automation and Robotics

Subject Code : DI04041041

Subject Name : Power Plant Automation

w. e. f. Academic Year:	2025-26
Semester:	4th
Category of the Course:	PCC

Prerequisite:	Basic Knowledge of Automation Components, Control System, Industrial Drawings.
Rationale:	Power generation is one of the most automated and critical engineering sectors. Diploma engineers in Automation & Robotics must understand the fundamental working principles of different power plants, with a specific emphasis on thermal power plants where automation is extensively used. This course introduces students to: • Power plant types and layouts • Major equipment in thermal power stations • Control loops essential for plant operation • Latest industry practices used by **Major Technology Providers** • Different case studies ; **IoT and digital monitoring** in modern power plants This competency prepares diploma engineers for roles in plant automation, commissioning, operation, and maintenance.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
1	Understand various types and layouts of power plants with special emphasis on thermal power plant.	R, U
2	Draw and Explain the major equipment and systems used in thermal power plants.	R, U
3	Understand Process Flow Diagram and Piping and Instrumentation Drawings	U, A
4	Apply control loop principles for automation of power plant processes.	R, U, A
5	Summarize case studies and modern trends in power plant automation.	U, A

**Revised Bloom's Taxonomy (RBT)*

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE(E)	PA(M)	PA(I)	ESE(V)	
3	0	0	3	70	30	0	0	100

Course Content:

Unit	Topics and Sub-topics	No. Of Hrs.	% Weightage
Unit – I Introduction to Power Plants	1.1 Overview of Power Plants 1.1a History of Power Generation in INDIA 1.1b Classification of power plants: Thermal, Nuclear, Hydroelectric, and Renewable Energy-based. 1.1c Importance and role of power plants in the energy sector. 1.1d Discuss the role of renewable energy power plants in modern energy systems. 1.2 Layouts of Power Plants 1.2a Nuclear 1.2b Hydroelectric 1.2c Thermal power plant 1.3 Major Components of Power Plants 1.3a Nuclear 1.3b Hydroelectric 1.3c Thermal power plant 1.4 Advangtes and Distavnatages 1.4.a Nuclear 1.4.b Hydroelectric 1.4.c Thermal power plant 1.5 Rankine Cycle in thermal power plants 1.5.a.1 Arrangement of components used for steam power plant 1.5.a.2 pv diagram Ts diagram	06	20
Unit – II Major Equipment of Thermal Power Plants	2.1 High Pressure Boilers 2.1.1a La Mont Boiler 2.1.1b Benson Boiler 2.1.1c Super Critical Boiler & its Advantages 2.1.1d Boiler Accessories a. Economiser	14	25

	b. Air Preheater c. Super heater d. Soot blower 2.2 Steam Turbines 2.2.1a Classification: Impulse and Reaction turbines. 2.2.1b Compounding of Steam Turbine a. Velocity compounding b. Pressure compounding c. Pressure and Velocity compounding d. Advantages and Disadvantage of Velocity Compounding 2.2.1c Industrial Steam Turbines a. Extraction Turbine b. Back Pressure c. Exhaust Turbine 2.3 Condensers 2.3.1. Elements of Steam Condensing Plants 2.3.2. Advantages of Condenser 2.3.3. Open Cycle Condensing System 2.3.4. Closed Cycle Condensing System 2.3.5. Types of Steam Condensers a. Mixing or Jet b. Non-Mixing or Surface c. Non-Conventional Direct Contact d. Evaporative		
Unit – III Auxiliary Systems	3.1 Coal handling and feeding systems. 3.1a Inplant Handling of Coal 3.1b Coal Preparation Plant 3.1c Transfer of Coal Related Equipment 3.1d Belt, Screw, Bucket, Grab Bucket, Skip Hoist. Flight Conveyors 3.1e Coal Dust and Its Control 3.1f Coal Cursing 3.1g Pulverised Fuel Handling System 3.1h Unit System 3.1i Central or Bin System 3.2 Ash handling systems and Dust Control 3.3a Ash Handling System 1. Mechanical Handling System	14	25

	2. Hydraulic Handling System 3. Pneumatic Handling System 4. Steam Jet System 3.3b Dust Handling System 1. Mechnical a. Gravitational b. Bag House c. Pulse jet d. Cyclone 2. Electrical a. ESP 3.3 Water treatment and feedwater systems 3.3a Necessary of Feedwater Treatment 3.3b Different impurities in water 1. Undissolved and suspended 2. Dissolved salt and Minerals 3. Dissolved gases 4. Other materials (oil, acid etc) 3.3c Effects of Water Impurities 3.3d Internal Water Treatment 3.3e External Water Treatment		
Unit – IV Instrumentation & Automation Systems	4.1.Introduction to Control Loops 4.1.a Concept of closed-loop control. 4.1.b Different Veariables in Control loop 4.2.Key Control Loops in Thermal Power Plants P&ID 4.2a Boiler Control Loop • The main in-line instruments for a drum-type boiler • Two-element feedwater control. • Three-element feedwater system, plus density compensation with drum pressure 4.2b Closed-loop control of parallel fans with balancing controls 4.2c Closed-loop air/fuel ratio control 4.2d Control system used to distribute the steam generated by a heat recovery steam generator (HRSG) 4.3.Safety Interlocks • boiler safety interlocks	06	15

	4.4.Optimization • Introduction • List type of optimization used in thermal powerplant		
Unit – V **Case Studies**	5.1 Present a case study on a automation system of thermal power plant's and discuss its factors. 5.2 Analyse a failure incident in power plant automation and suggest improvements. 5.2a Analysis of incidents caused by instrumentation or automation failures. 5.2b Root cause analysis and corrective measures. 5.3 A case study: instrumentation upgrades significantly improved power plant performance. 5.3a Case studies on performance improvement through upgraded instrumentation. 5.3b Reduction in emissions and compliance with environmental standards 5.4 Explain the challenges faced in integrating renewable energy systems into conventional power plants. 5.5 Role of AI and machine learning in predictive maintenance.	05	15
	Total	**45**	**100**

AFFECTIVE DOMAIN OUTCOMES:

The following sample Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned COs and PrOs. More could be added to fulfil the development of this competency.

a) Work as a leader/a team member for assigned student activity.
b) Follow safety practices and procedure in Lab.
c) Realize the importance of engineering for societal development.
d) Develop gradually the engineering mindset in day-to-day observation

SUGGESTED STUDENT ACTIVITIES:

Other than the classroom and laboratory learning, the following co-curricular activities are suggested for students. These activities enrich practical understanding and accelerate attainment of course outcomes. Students should perform these activities in groups and prepare **reports of about 5 pages** for each activity. They must also **collect physical evidences** (photos, screenshots, certificates, diagrams, calculations, etc.) for their portfolio, which will be useful during placement interviews.

Visit Report on Power Generation Plant (Thermal/Hydro/Solar/Waste-to-Energy)

- Visit a nearby power plant or virtual plant tour.
- Document layout, major equipment, control room architecture, and automation systems.
- Write observations on safety systems and instrumentation practices.

Case Study on Any Major Power Plant Failure / Incident

- Analyze an automation or instrumentation-related failure.
- Identify root causes using RCA techniques.
- Suggest improvements and preventive strategies.

Develop a P&ID Portfolio of Three Power Plant Systems

Create detailed P&ID diagrams for:

- Boiler feedwater system
- Condenser & cooling tower system
- Coal handling and ash handling systems

Use Draw.io or QElectroTech.
Attach screenshots and symbol explanations in the report.

Prepare a Comparative Study of DCS Platforms (ABB vs Siemens vs GE)

- Compare architecture, controllers, I/O modules, communication protocols, HMI features.
- Identify which industries prefer each vendor and why.
- Highlight strengths and limitations.

Design a SCADA Mini Project

- Create a SCADA screen for boiler/turbine/energy monitoring using ScadaBR or Node-RED.
- Include data tags, alarms, trends, and basic graphics.
- Prepare demonstration screenshots.

Energy Audit Study of a Thermal Power Plant (Real or Virtual)

- Study energy flow, heat losses, cycle efficiency, boiler and turbine efficiency.
- Suggest energy-saving methods and optimization opportunities.

Report on Renewable–Thermal Hybrid Power Systems

- Study how solar PV/Wind can be integrated with thermal power.
- Discuss energy storage, load balancing, forecasting, and hybrid SCADA architecture.

Create a Digital Twin Concept Model

- Using available simulation tools (MATLAB, Python, SimScape, Simulink).
- Represent a boiler or turbine as a simple dynamic mathematical model.
- Explain how digital twins help in predictive maintenance.

Study of Feedwater Treatment & DM Plant Operation

- Document impurities in feedwater, treatment methods, regeneration cycles.
- Include photos/diagrams of DM tanks, softeners, filters, deaerators.
- Explain significance for boiler life.

Industrial Standards & ISA Symbols Handbook

- Prepare a mini-handbook summarizing:
    - ISA instrumentation symbols
    - P&ID symbols
    - Control loop icons
    - Valve/actuator representations
- Useful for job interviews in instrumentation & automation.

Prepare a Cost Estimation / Budget Report for Automation Upgrade

- Identify major components (PLC/DCS panels, sensors, transmitters, valves).
- Estimate costs using online catalogs (ABB, Siemens, Emerson).
- Prepare a small proposal for upgrading automation in a small boiler plant.

AI/ML Applications in Power Plant Automation

- Study real industrial use cases of predictive maintenance.
- Propose a simple ML model idea (vibration monitoring, temperature anomaly detection).
- Collect research papers, screenshots, and insights.

SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES

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) Guide student(s) in undertaking micro-projects.

c) ***'L' in section No. 4*** means different types of teaching methods that are to be employed by teachers to develop the outcomes.
d) About ***20% of the topics/sub-topics*** which are relatively simpler or descriptive in nature is to be given to the students for ***self-learning***, but to be assess educing different assessment methods.
e) With respect to ***section :*** SUGGESTED STUDENT ACTIVITIES, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
f) Guide students on how to address issues on environ and sustainability

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 is given here. This has to match the competency and the COs.Similar micro-projects could be added by the concerned course teacher:

1. Design a P&ID for a boiler drum level control system.
2. Develop a SCADA dashboard for monitoring a small thermal power plant.
3. Create a simulation model of a two-element drum level control loop.
4. Build a coal handling and feeding sequence using OpenPLC.
5. Prepare a miniature PLC logic for boiler safety interlocks.
6. Develop a digital layout model of a thermal power plant.
7. Create a miniature Rankine cycle animation using open-source tools.
8. Draw comparative P&ID diagrams of open and closed cycle condenser systems.
9. Develop a Node-RED dashboard for integrating renewable energy with grid power.
10. Build a simple digital twin model of feedwater control using MATLAB/Simulink.
11. Create a vibration monitoring demo using simulated turbine data.
12. Design an ash handling process sequence (mechanical/pneumatic).
13. Develop a cause-and-effect matrix for boiler trip conditions.
14. Create an HMI screen for monitoring temperature, pressure, and flow.
15. Prepare a case-based micro-project on ABB/Siemens/GE DCS architecture.
16. Simulate ESP (Electrostatic Precipitator) control logic.
17. Develop a steam temperature control loop using ScadaBR.

18. Create a micro-project on condenser vacuum monitoring instrumentation.
19. Simulate a fuel-air ratio optimization loop.
20. Build a micro-project on predictive maintenance using sample AI/ML datasets.

SUGGESTED LEARNING RESOURCES:

S. No.	Title of Book	Author	Publication with Place, Year, and ISBN
1	Power Plant Engineering	Domkundwar, Arora	Dhanpat Rai & Co., India, 2020, ISBN: 978-81-7700-483-1
2	Power Plant Instrumentation and Control Handbook	Philip Kiameh	Elsevier, USA, 2014, ISBN: 978-0-12-391855-8
3	Instrumentation for Process Measurement and Control	Norman A. Anderson	CRC Press, USA, 2017, ISBN: 978-1-138-74168-6
4	Introduction to SCADA and PLCs	David Bailey, Edwin Wright	Elsevier, UK, 2003, ISBN: 978-0-7506-5796-5
5	Modern Power Station Practice	British Electricity International	Butterworth-Heinemann, UK, 1990, ISBN: 978-0-408-01566-5
6	Power Plant Engineering	P.K. Nag	McGraw Hill Education, India, 2017, ISBN: 978-0-07-068113-2
7	Industrial Instrumentation	Donald P. Eckman	Wiley Eastern, India, 1990, ISBN: 978-81-224-0778-4
8	Control of Power Plants and Power Systems	Allan Wood	Springer, USA, 1994, ISBN: 978-1-4612-8494-3
9	Practical Power Plant Engineering	Zark Bedalov	Wiley, USA, 2020, ISBN: 978-1-119-58362-0
10	Distributed Control Systems	Michael P. Lucas	Van Nostrand Reinhold, USA, 1990, ISBN: 978-0-442-01207-2
11	Instrumentation Engineers Handbook (Vol. 1 & 2)	Bela G. Liptak	CRC Press, USA, 2016, ISBN: 978-1-4822-6276-0 (Vol. 1)

SOFTWARE/LEARNING WEBSITES:

SOFTWARES

1. **OpenPLC**
   - A free, open-source platform for PLC programming.
   - Use for creating control systems for power plants and simulating automation tasks.
   - Website
2. **ScadaBR**
   - Open-source SCADA software for monitoring and control applications.
   - Ideal for creating small-scale SCADA systems for learning purposes.
   - Website

3. **DWSIM**
   - Open-source chemical process simulator.
   - Can be used to simulate power plant processes like the Rankine cycle.
   - Website
4. **MATLAB/Simulink**
   - For simulating control systems, DCS architecture, and power plant processes.
   - Offers advanced modeling and real-time simulation capabilities.
   - Website
5. **Node-RED**
   - A flow-based programming tool for IoT integration.
   - Use to connect IoT devices and visualize power plant data.
   - Website
6. **ThingSpeak**
   - An open-source IoT platform for data collection and visualization.
   - Suitable for monitoring and analyzing plant data.
   - Website
7. **AutoCAD Plant 3D**
   - For creating P&ID diagrams and layouts for power plant systems.
   - Industry-standard for engineering design and drafting.
   - Website
8. **KEPServerEX**
   - An OPC server platform for SCADA integration.
   - Useful for connecting field devices with SCADA/DCS systems.

LEARNING WEBSITES:

1. **ABB Power Plant Automation Solutions**
   - Learn about modern power plant automation systems and instrumentation solutions.
2. **Siemens Power Plant Automation**
   - Offers detailed insights into SCADA, DCS, and safety systems for power plants.
3. **GE Grid Solutions**
   - Explore advanced automation technologies for grid and power plant operations.
   - Website
4. **YouTube Channels**
   - **NPTEL (National Programme on Technology Enhanced Learning):** Lectures on instrumentation and automation.
     YouTube Channel

- **RealPars:** Tutorials on PLC, SCADA, and automation systems.
  YouTube Channel

5. **Instrumentation Tools**
   - A comprehensive platform for learning instrumentation and control systems.
   - Website
6. **Coursera and edX**
   - Online courses on SCADA, PLC programming, and industrial automation by top universities.
   - Coursera
   - edX
7. **ISA (International Society of Automation)**
   - Offers technical resources and certifications in industrial automation.
   - Website
8. **PLC Academy**
   - Learn about PLC programming, SCADA, and industrial automation concepts.
   - Website

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