TRIPURA UNIVERSITY
(A CENTRAL UNIVERITY)

CURRICULUM STRUCTURE

OF

4 YEARS

BACHELOR OF TECHNOLOGY

DEPARTMENT OF ELECTRICAL ENGINEERING(EE)

8th Semester

2021

8th SEMESTER

Sl. No.	Course Category	Subject Code	Subject Title	L	T	P	Contact Hours/week	Credit	Full Marks
1.	Program Elective-4	PEEE801/1	Power System Dynamics & Control	3	0	0	3	3	100
		PEEE801/2	Electrical and Hybrid Vehicles						
		PEEE801/3	Industrial Process Control						
2.	Program Elective-5	PEEE 802/1	HVDC transmission System	2	0	0	2	2	100
		PEEE 802/2	Electrical Energy Conservation and Auditing						
		PEEE 802/3	Line-Commutated and Active PWM Rectifiers						
3.	Open Elective-1	OEEE 803	Annexure-III	3	0	0	3	3	100
4.	Open Elective-2	OEEE 804	Annexure-IV	2	0	0	2	2	100
5.	Project - 3	PREE 805	Project Work Final	0	0	12	12	6	200
6.	Seminar - 2	SEEE 806	Seminar on Contemporary Engineering Topics - II	0	0	2	2	1	100
7.	Online Course	SW EE 807	SWAYAM Courses#	0	0	0	0	1	100
			Total :	10	0	14	24	**18**	**800**

POWER SYSTEM DYNAMICS AND CONTROL

Course Code	PEEE-801/1
Course Title	Power System Dynamics & Control
Number of Credits	3 (L: 3, T: 0, P: 0)
Prerequisites	Power System, Electrical Machine
Course Category	Program Elective-4
Number of classes	36 hours

Course Outcome:

CO Number	CO Description	K-level
CO-1	Understand the problem of power system stability and its impact on the system.	K2
CO-2	Apply different methods to improve stability	K3
CO-3	Apply different power system components for the study of stability	K3
CO-4	Understand the HVDC and FACTS controllers	K2
CO-5	Analyze linear dynamical systems and apply numerical integration methods	K4

Course Content:

Module 1: Introduction to Power System Operations (8 hours):

Introduction to Power System Operations: Introduction to power system stability. Power system operations and control, Stability problems in power system, Impact on Power System Operations and control, Analysis of Linear Dynamical System and Numerical Methods: Analysis of dynamical System, Concept of Equilibrium, Small and Large Disturbance Stability, Modal Analysis of Linear System, Analysis using Numerical Integration Techniques, Issues in Modeling; Slow and Fast Transients, Stiff System.

Module 2: Modeling of Synchronous Machines and Associated Controllers (10 hours)
Modeling of Synchronous Machines and Associated Controllers: Modeling of synchronous machine: Physical Characteristics, Rotor position dependent model, D-Q Transformation, Model with Standard Parameters, Steady-State Analysis of Synchronous Machine, Short Circuit Transient Analysis of a Synchronous Machine, Synchronization of Synchronous Machine to an Infinite Bus, Modeling of Excitation and Prime Mover Systems, Physical Characteristics and Models, Excitation System Control, Automatic Voltage Regulator, Prime Mover Control Systems, Speed Governors.

Module 3: Modeling of other Power System Components (8 hours):

Modeling of other Power System Components, Modeling of Transmission Lines and Loads, Transmission Line Physical Characteristics, Transmission Line Modeling, Load Models - induction machine model, Frequency and Voltage Dependence of Loads, Other Subsystems - HVDC and FACTS controllers.

Module 4: Stability Analysis (10 hours):

Stability Analysis: Angular stability analysis in Single Machine Infinite Bus System, Angular Stability in multimachine systems - Intra-plant, Local and Inter-area modes, Frequency Stability: Centre of Inertia Motion, Load Sharing: Governor droop, Single Machine Load Bus System: Voltage Stability, Introduction to Torsional Oscillations and the SSR phenomenon, Stability Analysis Tools: Transient Stability Programs, Small Signal Analysis Programs, Enhancing System Stability: Planning Measures, Stabilizing Controllers (Power System Stabilizers), Operational Measures-Preventive Control, Emergency Control.

References / Suggested Learning Resources:

1. K.R. Padiyar, “Power System Dynamics, Stability and Control, B. S. Publications, 2002.
2. P. Kundur, “Power System Stability and Control, McGraw Hill, 1995.
3. P. Sauer and M. A. Pai, “Power System Dynamics and Stability, Prentice Hall, 1997.

ELECTRICAL AND HYBRID VEHICLES

Course Code	PEEE 801/2
Course Title	Electrical and Hybrid Vehicles
Number of Credits	3 (L: 3, T: 0, P: 0)
Prerequisites	Electrical Machine-I & II, Power Electronics and Control System-I
Course Category	Program Elective-4(PE-4)
Number of classes	36 hours

Course Outcome:-
After completion of the course, students will be able to:

CO No	CO Description	K-level
PEEE801/2.1	Illustrate the models to describe hybrid vehicles and compare their performance.	K2
PEEE801/2.2	Develop the different train topologies and power flow control in electric vehicles.	K3
PEEE801/2.3	Explain the use of different types of energy storage devices used for hybrid electric vehicles.	K2
PEEE801/2.4	Interpret the different energy management strategies used in hybrid and electric vehicles.	K2

Course Content:-

Module- 1: Introduction (10 hours)

Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance. Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.

Module- 2: Electric Trains (10 hours):

Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis. Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

Module- 3: Energy Storage (8 hours):

Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems.

Module- 4: Energy Management Strategies (8 hours):

Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies. Case Studies: Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).

References/ Suggested Learning Resources:-

1. C. Mi, M. A. Masrur and D. W. Gao, “Hybrid Electric Vehicles: Principles and Applications
with Practical Perspectives”, John Wiley & Sons, 2011.
2. S. Onori, L. Serrao and G. Rizzoni, “Hybrid Electric Vehicles: Energy Management Strategies”, Springer,2015.
3. M. Ehsani, Y. Gao, S. E. Gay and A. Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design”, CRC Press, 2004.
4. T. Denton, “Electric and Hybrid Vehicles”, Routledge, 2016.
5. Iqbal Husain, ELECTRIC and HYBRID VEHICLES, Design Fundamentals, CRC Press, 2003.
6. Ali Emadi, Advanced Electric Drive Vehicles, CRC Press, 2015.

INDUSTRIAL PROCESS CONTROL

Course Code	PEEE 801/3
Course Title	Industrial Process Control
Number of Credits	3 (L: 3, T: 0, P: 0)
Prerequisites	Control System, Measurement & Instrumentation
Course Category	Program Elective-4(PE-4)
Number of classes	36 hours

Course Outcomes: After Completing this course, students will be able to

CO No	CO Description	K-level
PEEE-801/3:OC.01	Understand about the different Process Control Systems and their working principles.	K2
PEEE-801/3:OC.02	Design of Process Controllers using different methods and implementations.	K6
PEEE-801/3:OC.03	Understand about Feed-forward Control, Ratio Control, Multi-loop Control of Process and their implementations.	K2
PEEE-801/3:OC.04	Explain about Final Control elements of Process Control and Supervisory control of large Industrial Plants.	K2

Module 1: Concepts of different Type of Processes (10 Hours)

Concept of Processes, Components of Process Control, Process dynamics of different type of Industrial processes, Process Control terminologies. Modeling of Standard first order and second order type processes with examples - flow control, level control, Temperature Control, Pressure control and Humidity Control, Capacitance type process, Resistance type process, Single time constant type process, Multiple time constant type process, Interactive and non-interactive type processes. Auto/Manual modes of operation. Bump-less transfer of Processes.

Module 2: Design and Implementation of Controllers for Process Control Systems (12 Hours)

Controller Implementation : Implementations of Proportional and Integral Control, their Saturation, Characteristics of P, PI, PD, and PID controllers for Process Control Systems, Provision for anti-integral windup and anti-derivative kick. Tuning of P, PI, PID Controllers using Process reaction Curve of Industrial Processes, Cohen-Coon method, Ziegler-Nichol's tuning method for implementation of PI, PD, and PID Controllers, Design of controllers with auto-tuning method employing relay feedback, Frequency domain design for Controllers. Flow Loop control design Using Caldwell's and Sundaresan's Methods.

Module 3: Advanced Process Control employing Ratio, feed-forward and Multi-loop(8 Hours.)

Structure & Implementations of Feed-forward control, Ratio Control, Multi-loop and Cascade control with examples-their Transfer functions, advantages & disadvantages and their modifications. Interaction and decoupling, Non-linear effects in plants and controllers. Boiler Drum Level Control-different techniques.

Module 4: Final Control elements and sequential & Supervisory Control (10 Hours)

Final control elements in process control loop. Type of Actuators: Pneumatic, Electrical, Hydraulic. Positioners. Pneumatic to electrical Signal and. electrical to pneumatic signal converters. Control valves: Classifications & Characteristics of Control Valves, single stem and double stem sliding valves, Valve sizing technique. Concepts of Modulating and Sequential Control. Structure of Modulating Control loops. Supervisory control: Objectives and Implementation in Process Control.

References/ Suggested Learning Resources:-

1. Smith & Corripio, Principles and Practice of Automatic Process Control.
2. Eckman, Automatic Process Control.
3. Shinskey, Process Control Systems.
4. Process Systems Analysis and Control - Coughanowr & Koppel
5. Anand, M.M.S., Electronic Instruments & Instrumentation techniques, PHI, 2004
6. D. Patranabish, Industrial Instrumentation, PHI
7. Krishna Kanth, Computer based Industrial Control, PHI, 2005
8. SeborG-Edgar-Doyle, Process Dynamics and Control, John wiley, 2011
9. C. D. Johnson, Process Control Instrumentation Technology, PHI, 2004
10. Surekha Bhanot, Process Control Principal and Applications, PHI, 2008.
11. Stephanopoulous, Chemical Process Control, PHI, 1984

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HVDC TRANSMISSION SYSTEMS

Course Code	PEEE 802/1
Course Title	HVDC Transmission Systems
Number of Credits	02 (2L:0T:0P)
Prerequisites	Basic circuit laws, Power system I, Power Electronics
Course Category	Program Elective (PC)
Number of classes	26

Course Outcomes:

After Completing this course, students will be able to		K-Level
CO -1	Understand the advantages of dc transmission over ac transmission.	K2
CO -2	Understand the operation of Line Commutated Converters and Voltage Source Converters.	K2
CO-3	Understand the control strategies used in HVDC transmission system.	K2
CO -4	Understand the improvement of power system stability using an HVDC system.	K2

<u>Course Content:</u>

Module 1: dc Transmission Technology (6 hours)

Comparison of AC and dc Transmission (Economics, Technical Performance and Reliability). Application of DC Transmission. Description of DC transmission system: types of DC link, converter station. Planning for HVDC transmission. Modern trends in HVDC Technology. Operating problems of HVDC transmission.

Module 2: Analysis of Line Commutated and Voltage Source Converters (7 hours)

Line Commutated Converters (LCCs): Six pulse converter, Analysis neglecting commutation overlap, harmonics, Twelve Pulse Converters. Inverter Operation. Effect of Commutation Overlap. Expressions for average dc voltage, AC current and reactive power absorbed by the converters. Voltage Source Converters (VSCs): Two and Three-level VSCs. PWM schemes: Selective Harmonic Elimination, Sinusoidal Pulse Width Modulation. Analysis of a six pulse converter.

Module 3: Control of HVDC Converters: (7 hours)

Principles of Link Control in a LCC HVdc system. Control Hierarchy, Firing Angle Controls–

Phase-Locked Loop, Current and Extinction Angle Control, Starting and Stopping of a Link. Higher level Controllers Power control, Frequency Control, Reactive Power Control. Principles of Link Control in a VSC HVdc system. Telecommunication requirements

Module 4: MTDC Links and Stability Enhancement using HVDC Control (6 hours)

Multi-Terminal and Multi-Infeed Systems. Series and Parallel MTdc systems using LCCs. MTdc systems using VSCs. Protection of MTDC Systems. Potential Applications MTDC Systems. Basic Concepts: Power System stability- Voltage and Frequency Stability. Power Modulation: basic principles – synchronous and asynchronous links.

Text/References:

1. K. R. Padiyar, "HVDC Power Transmission Systems", New Age International Publishers, 2011.
2. J. Arrillaga, "High Voltage Direct Current Transmission", Peter Peregrinus Ltd., 1983.
3. E. W. Kimbark, "Direct Current Transmission", Vol.1, Wiley-Interscience, 1971.

ELECTRICAL ENERGY CONVERSATION AND AUDITING

Course Code	PEEE 802/2
Course Title	Electrical Energy Conservation and Auditing
Number of Credits	2 (L: 2; T: 0; P: 0)
Prerequisites	Power System
Course Category	Program Elective-2
Number of Classes	26

Course Outcome: After Completion of this course students will able to

CO Number	CO Description	K-level
CO-1	Understand different energy resources, energy consumptions, emission & pollution.	K2
CO-2	Explain energy Audit System.	K2
CO-3	Categorize different energy Systems.	K4
CO-4	Understand different types of energy storage & conservation System.	K2

Module-I Energy Resources and Generation of Power (8 hours)

Energy Resources in general, present scenario, Energy consumption and acts, Environmental aspects of Thermal, Nuclear and hydroelectric power generations, types of emission from various sectors, co-relation between emission & pollution. Kyoto protocol, and carbon credit etc.

Module-II Energy Audit (6 hours)

Energy audit: primary and detail auditing. Energy management: Demand side management (DSM) and Supply side management(SSM), Supply side management through energy price control, Smart Grid – functions, features and technologies. The role of Reactive power management. Distributed generation (DG) and Microgrids:-features of distributed generations, technical issues of DG connection at distribution voltage level. Composition of Microgrid.

Module-III Renewable Energy Resources and Generation of Power (6 hours)

Renewable energy resources: Solar- solar thermal, solar PV, wind energy- prospects and status in national and global context, principles of wind energy conversion, wind monitoring system, VAWT and HAWT, selection of site for WTGS. Geothermal, Tidal, Bio-energy- Biomass and bio gas with gasifiers etc. Fuel cell. Mini and micro hydel power plant, micro turbine.

Module-IV Energy Storage and Conservation (6 hours)

Energy storage and conservation:- Types and methods of energy storage, Energy storage setups like Chemical, Thermal, Magnetic, fly wheel storage etc. Energy conservation – Concept of cogeneration, combined heat and power (CHP).

Reference / Text Books:

1. Energy Management Handbook (6th ed. 2007) – by Wayne C. Turner & Steve Doty, the Fairmont Press, Inc.
2. Guide to energy management, 6th Ed., - by Barney L. Capehart, Wayne CTurner, William J. Kennedy, The Fairmont Press, Inc.
3. Power Station Engineering and Economics – Skortzki, B. G. A. and Vopat W. A. McGraw Hill, NewYork.
4. Solar Energy Engg - Sayigh A. A. M - Academic Press.
5. Demand Side Management planning - Gelling C W et al. Fairmount Press, Lilbum, U S A.
6. Generation of Electrical Energy – B. R. Gupta, Eurasia Publishing House (Pvt) Ltd.

LINE-COMMUTATED AND ACTIVE PWM RECTIFIERS

Course Code	PEEE 802/3
Course Title	Line-Commutated and Active PWM Rectifiers
Number of Credits	2 (L: 2, T: 0, P: 0)
Prerequisites	Power Electronics
Course Category	Program Elective-5(PE-5)
Number of classes	24 hours

Course Outcome:-

After completion of the course, students will be able to:

CO No.	CO Description	K-level
PEEE802/3.1	Analyze the controlled rectifier circuits.	K4
PEEE802/3.2	Explain in basic operation and compare the performance of various power semiconductor devices and switching circuits.	K2
PEEE802/3.3	Illustrate the operation of line-commutated rectifiers – 6 pulse and multi-pulse configurations.	K2
PEEE802/3.4	Explain the operation of PWM rectifiers – operation in rectification and regeneration modes and lagging, leading and unity power factor mode.	K2

Course Content:-

Module- 1: Diode rectifiers and Thyristor rectifiers with passive filtering (6 hours):

Half-wave diode rectifier with RL and RC loads; 1-phase full-wave diode rectifier with L, C and LC filter; 3-phase diode rectifier with L, C and LC filter; continuous and discontinuous conduction, input current wave shape. Half-wave thyristor rectifier with RL and RC loads; 1-phase thyristor rectifier with L and LC filter; 3-phase thyristor rectifier with L and LC filter; continuous and discontinuous conduction, input current wave shape.

Module- 2: Multi-Pulse converter (6 hours)

Review of transformer phase shifting, generation of 6-phase ac voltage from 3-phase ac, 6-pulse converter and 12-pulse converters with inductive loads, steady state analysis, commutation overlap, notches during commutation.

Module- 3: Single-phase ac-dc single-switch boost converter (6 hours)

Review of dc-dc boost converter, power circuit of single-switch ac-dc converter, steady state analysis, unity power factor operation, closed-loop control structure.

Module- 4: Ac-dc bidirectional boost converter (6 hours)

Review of 1-phase inverter and 3-phase inverter, power circuits of 1-phase and 3-phase ac-dc boost converter, steady state analysis, operation at leading, lagging and unity power factors. Rectification and regenerating modes. Phasor diagrams, closed-loop control structure.

References/ Suggested Learning Resources:-

1. G. De, "Principles of Thyristorised Converters", Oxford & IBH Publishing Co, 1988.
2. J.G. Kassakian, M. F. Schlecht and G. C. Verghese, "Principles of Power Electronics", AddisonWesley,1991.
3. L. Umanand, "Power Electronics: Essentials and Applications", Wiley India, 2009.
4. N. Mohan and T. M. Undeland, "Power Electronics: Converters, Applications and Design", John Wiley & Sons, 2007.
5. R. W. Erickson and D. Maksimovic, "Fundamentals of Power Electronics", Springer Science & Business Media, 2001.

PROJECT WORK FINAL

Course Code	PR EE 805
Course Title	Project Work Final
Number of Credits	6 (L: 0, T: 0, P: 12)
Prerequisites	Nil
Course Category	Project (PR)
Number of classes	130 hours

Course Outcome:-

After completion of the course, students will be able to:

CO Number	CO Description	K-level
CO-1	Demonstrate a sound technical knowledge of their selected project topic	K2
CO-2	Develop the skill of working in a Team	K3
CO-3	Design engineering solutions to complex problems utilizing a systematic approach	K6
CO-4	Design the solution of an engineering project involving latest tools and techniques	K6
CO-5	Develop the skill of effective communication with engineers and the community at large in written an oral forms	K3
CO-6	Demonstrate the knowledge, skills and attitudes of a professional engineer	K2

Course Content:-

The project topic should be selected / chosen to ensure the satisfaction of the urgent need to establish a direct link between education, national development and productivity and thus reduce the gap between the world of work and the world of study. The course should have the following-

1) Develop sound knowledge about the domain of the project work.
2) Perform detailed study about various components of a project.
3) Learn to be an important member of a team for successful execution of a project work.
4) Study about methodologies and professional way of documentation and communication related to project work.
5) Develop idea about problem formulation, finding the solution of a complex engineering problem.
6) Develop project report as per the suggested format to communicate the findings of the project work.
7) Acquire the skill of effective oral communication to the fellow engineers and people in the society at large.
8) Develop knowledge of how to organize, scope, plan, do and act within a project thesis.
9) Familiarity with specific tools (i.e. hardware equipment and software) relevant to the project selected.
10) Demonstrate the implementation of a project work.