DR. BABASAHEB AMBEDKAR TECHNOLOGICAL UNIVERSITY, LONERE -402103

Dr. Babasaheb Ambedkar Technological University
(Established as a University of Technology in the State of Maharashtra)
(under Maharashtra Act No. XXIX of 2014)
P.O. Lonere, Dist. Raigad, Pin 402 103, Maharashtra
Telephone and Fax. : 02140 -275142
www.dbatu.ac.in

Structure and syllabus of
M. Tech.(Electrical Engineering 12293)

For Affiliation Colleges only

With effect from the Academic Year
2024-2025

M.Tech Electrical Engineering

Program Educational Objectives:

1. To prepare graduates to meet the challenges of modern society through viable engineering solutions.
2. To prepare graduates to develop economically viable cutting-edge technology for local industry. Need.
3. To prepare graduates to inspire next generation graduates as successful engineer/ entrepreneur, scientist and researcher.

Program Outcomes:

1. Ability to apply knowledge of science, mathematics, and engineering principles for solving problems.
2. Ability to identify, formulate and solve electrical power system problems
3. Ability to understand and use different software tools in the domain of Power electronics, power system and control system simulations.
4. Ability to design and conduct experiments and analyze and interpret data.
5. Ability to coherently work in a multidisciplinary team.
6. Demonstrate sensitivity towards professional and ethical responsibility.
7. Ability to communicate effectively in writing as well as through public speaking.
8. Demonstrate ability to appreciate and engage in lifelong learning.
9. Demonstrated knowledge of contemporary issues.
10. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
11. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.

M.Tech Electrical Engineering

M. Tech Course Structure and syllabus for Electrical (Electrical Engineering) AY 2024-25											
	Course Code	**Course Title**	**Teaching Scheme**			**Marking Scheme**			**Total Marks**	**Cr**	**Category**
			L	**T**	**P**	**CA**	**MSE**	**ESE**			
SEM-I	24AF2293PC101	Power System Modeling	3	1	-	20	20	60	100	4	PCC
	24AF2293PC102	Advanced Power Electronics	3	1	-	20	20	60	100	4	PCC
	24AF2293PE103	Program Elective-I	3	1	-	20	20	60	100	4	PE
	24AF2293PE104	Program Elective-II	3	1	-	20	20	60	100	4	PE
	24AF2612OE105	Research Methodology	4	-	-	20	20	60	100	4	ELC
	24AF2293PCL106	PG Lab-I	-	-	2	25		25	50	1	PCC
	24AF2293AU107	YOGA for Stress Management	2	-	-	50			50	-	Audit Course
		Total	**18**	**4**	**4**					**21**	
	Course Code	**Course Title**	**Teaching Scheme**			**Marking Scheme**			**Total Marks**	**Cr**	**Category**
			L	**T**	**P**	**CA**	**MSE**	**ESE**			
SEM-II	24AF2293PC201	AC /DC drives	3	1	-	20	20	60	100	4	PCC
	24AF2293PC202	Advance Power System Protection	3	1	-	20	20	60	100	4	PCC
	24AF2293PC203	Program Elective-III	3	-	-	20	20	60	100	3	PE
	24AF2293OE204	Open Elective I	3	-	-	20	20	60	100	3	OE
	24AF2293OE205	Intellectual Property& Rights**	3	-	-	20	20	60	100	3	OE
	24AF2293PCL206	PG Lab-III	-	-	2	25		25	50	1	PCC
	24AF2293PCL207	Seminar-I			2	25		25	50	1	PCC
	24AF2293IK208	IKS Bucket#	2	-	-	20	20	60	100	2	AEC/VEC/IKS
	24AF2293AU209	Disaster Management	2	-	-	50			50	-	Audit Course
		Total	**19**	**2**	**4**					**21**	

	Course Code	Course Title	Teaching Scheme			Marking Scheme			Total Marks	Cr	Category
			L	T	P	CA	MSE	ESE			
SEM-III	24AF2293PE301	Program Elective IV	3	-	-	20	20	60	100	3	PE
	24AF2293OE302	Open Elective II	3	-	-	20	20	60	100	3	OE
	24AF2293MD303	Multidisciplinary Minor	3	-	-	20	20	60	100	3	MDM***
	24AF2293ES304	Environmental Studies	4	-	-	20	20	60	100	4	HSSM**
	24AF2293PC305	Project I***	-	-	-	20	20	60	100	10	ELC
		Total	**13**							**23**	
SEM-IV	24AF2293PC401	Project II	-	-	-	20	20	60	100	20	ELC
		Total								**20**	

Credit Distribution

SEMI	SEM II	SEM III	SEMIV	Total
21	21	23	20	84

For M.Tech degree completion : Students must complete min 08 Credits of Open Elective, 20Credits of Program Elective, 14 Credits of HSSM, 4 credits of co-curriculum courses and 22credits of Experiential learning courses from Open courses slots Institutes are free to manage the slots according to BoS inputs.

Program Elective I Courses

Course Code	Course Title	Credits
24AF2293PE103(A)	Modern Control System	4
24AF2293PE103(B)	Advanced Topics in Power System	4
24AF2293PE103(C)	Renewable Energy Systems	4
24AF2293PE103(D)	Advanced Digital Signal Processing	4

Program Elective II Courses

Sr. No.	Course Title	Credits
24AF2293PE104(A)	Electrical Transients in Power System	4

24AF2293PE104(B)	Power Electronics for Renewable Energy Systems	4
24AF2293PE104(C)	Power Electronics and Control	4

Program Elective III Courses

Course Code	Course Title	Credits
24AF2293PC203(A)	Power Sector Economics Restructuring & Regulation	3
24AF2293PC203(B)	Distributed generation and micro grid	3
24AF2293PC203(C)	Embedded Systems	3

Program Elective IV Courses

Course Code	Course Title	Credits
24AF2293PE301(A)	Application of Power Electronics to Power System	3
24AF2293PE301(B)	Electric and Hybrid Vehicles	3
24AF2293PE301(C)	Control System design and estimation	3

Open Elective I (Bucket)

Couse Code	NPTEL Course	Credits	Name of Instructor	Host Institute	Link
24AF2293OE204A	New Labor Codes of India	3	Prof. K D Raju	IIT Kharagpur	https://onlinecourses.nptel.ac.in/noc23_lw05/preview
24AF2293OE204B	Urban Utilities Planning: Water Supply, Sanitation and Drainage	3	Prof. Debapratim Pandit	IIT Kharagpur	https://onlinecourses.nptel.ac.in/noc23_ar08/preview
24AF2293OE204C	Environment and Development	3	Prof. NgamjahaoKipgen	IIT Guwahati	https://onlinecourses.nptel.ac.in/noc21_hs83/preview
24AF2293OE204D	Entrepreneurship	3	Prof. C Bhaktavatsala Rao	IITMadras	https://onlinecourses.nptel.ac.in/noc20_mg35/preview

Open Elective II (Bucket)

Course Code	NPTEL Course	Credits	Name of Instructor	Host Institute	Link
24AF2293OE302**A**	Student Psychology	3	Dr. S.Renukadevi	National Institute of Technical Teachers Training and Research, Chennai	https://onlinecourses.swayam2.ac.in/ntr19_ed23/preview
24AF2293OE302**B**	Business To Business Marketing(B2B)	3	Prof. J. K. Nayak	IIT Roorkee	Business To Business Marketing (B2B) - Course(nptel.ac.in)
24AF2293OE302**C**	Organizational Behaviour	3	Prof. M. P.Ganesh	IIT Hyderabad	Organizational Behaviour - Course(nptel.ac.in)
24AF2293OE302**D**	Principles Of Economics	3	Prof. SabujKumar Mandal	IIT Madras	Principles Of Economics - Course(nptel.ac.in)

Multidisciplinary Minor bucket

Course Code	NPTEL Course	Credits	Name of Instructor	Host Institute	Link
24AF2293MD30A	Design Of Mechatronic Systems	3	Prof. Prasanna Gandhi	IIT Bombay	Design Of MechatronicSystems - Course(nptel.ac.in)
24AF2293MD30B	Ethical Hacking	3	Prof. Indranil Sengupta	IIT Kharagpur	Ethical Hacking - Course(nptel.ac.in)
24AF2293MD30C	Sustainable Power Generation Systems	3	Dr.Pankaj Kalita	IIT Guwahati	Sustainable PowerGeneration Systems - Course(nptel.ac.in)

24AF2293MD30D	Components And Applications of Internet of Things	3	Dr. Sanjoy Kumar Parida	Indian Institute of Technology Patna	https://onlinecourses.swayam2.ac.in/arp20_ap03/preview

IKS (Bucket)

Course Code	NPTEL Course	Credits	Name of Instructor	Host Institute	Link
24AF2293IK208A	Indian Knowledge System (IKS):Concepts and Applications in Engineering	4	Prof. B. Mahadevan, Dr. Vinayak Rajat Bhat, Dr. R VenkataRaghavan	Prof. B. Mahadevan, Dr. Vinayak Rajat Bhat, Dr. R VenkataRaghavan	https://onlinecourses.swayam2.ac.in/imb23_mg53/preview
24AF2293IK208B	Indian Knowledge System (IK):Humanities and Social Sciences	4	Prof. B. Mahadevan, Dr. Vinayak Rajat Bhat, Dr. R VenkataRaghavan	Indian Institute of Management Bangalore(IIMB) ,Chanakya University, Bangalore	https://onlinecourses.swayam2.ac.in/imb23_mg55/preview
24AF2293IK208C	Ancient Indian Management	2	Dr. Alka Jain	Taxila Business School	https://onlinecourses.swayam2.ac.in/aic22_ge19/preview

SyllabusforElectrical Engineering (M.TechFirstyear)

SEMESTERI

24AF2293PC101: POWER SYSTEM MODELLING 04 Credits

Pre-Requisites: Engineering mathematics, Circuit analysis, Electrical machine and power system analysis, power electronics

Course Objective:

To describe characteristics and appropriate mathematical models for representations of power system components such as synchronous machine, transmission line, transformer, induction motor, excitation systems and non-electrical components in power system dynamic studies. Review of steady state and transient performance characteristic of synchronous machine.

CourseOutcomes:

CO1	Develop power system components modelling and analyze their performance
CO2	Develop modelling of synchronous machine and analyze its performance
CO3	Perform steady state and dynamic analysis on simulation models
CO4	Understand configuration and functioning of synchronous machine excitation system.
CO5	Develop excitation system components modelling and analyze their performance.
CO6	Understand and transmission line, load and reactive power compensator modelling.

24AF2293PC101: POWER SYSTEM MODELING

Course Content

UNIT-1: Modelling of Power System Components: [8 Hours]
The need for modelling of power system, different areas of power system analysis. Models of nonelectrical components like boiler, steam & hydro-turbine & governor system. Transformer modelling such as auto-transformer, tap-changing & phase shifting transformer.

UNIT-2: Synchronous machine modelling [8 Hours]
Model required for steady-state analysis. The development of model required for dynamic studies. The current & flux linkage models using Park's transformation leading to simulation as linear model.

UNIT-3: Analysis of synchronous machine modelling [6 Hours]
Synchronous machine connected to an infinite bus, its simulation for steady-state condition.

UNIT-4 Excitation systems [7 Hours]
Simplified view of excitation control. Excitation configuration, primitive systems, Definitions of voltage response ratio & exciter voltage ratings.

UNIT-5 Excitation system modelling [7 Hours]
Excitation control systems using dc generator exciter, alternator-rectifier, alternator SCR, and voltage regulators such as electro-mechanical and solid state. Modelling of excitation systems.

UNIT-6-Transmission line, SVC and load modelling: [6 Hours]
Transmission line modelling, Modelling of static V AR compensators, load modelling

Reference books:

1. P. Kundur, "Power System Stability and Control", McGraw-Hill, 1993.
2. R.Ramunujam," Power System Dynamics Analysis and Simulation, PHI Learning Private Limited, New Delhi, 2009.
3. Electric Power Systems: B.M. Weddy and B.J. Cory, John Wiely and Sons, Fourth adition (2002).
4. Power System Analysis and Design :J. Duncan Glover, MulukutlaS. Sarma, Thomson Brooks/cole/ Third Edition (2003)

24AF2293PC102: ADVANCED POWER ELECTRONICS Credits04

Pre-Requisites: Power Electronics, Circuit theory.

24AF2293PC102: ADVANCED POWER ELECTRONICS

Course Objectives:

To understand configuration and characteristics of different power semiconductor devices used in power system operation and control. To analyses principle of operation of various power converter used in power system operation. To understand various advance power conversion techniques using power semiconductor devices. To explore the ability of advance power conversion techniques in harnessing renewable energy sources.

Course Outcomes:

Upon successful completion of this course the students will be able to:

CO1	Understand the behaviour of power semiconductor devices operated as power switches.
CO2	analyze operation of various power converters
CO3	Understand advance power conversion techniques
CO4	Apply power conversion technology for exploring RES
CO5	Ability to design and test power electronic circuits in the laboratory

24AF2293PC102: ADVANCED POWER ELECTRONICS

Course content:

UNIT-I Overview of Switching Power Devices: [8 Hours]
Solid State Power Semi-conducting Devices: Review of the thyristors, traic, GTO, transistor MOSFET and other modem power devices (IGBT, SIT, SITCH, MCT), characteristics ratings,commutation methods, protection and requirement of firing circuits.

UNIT-II Phase Controlled Rectifiers: [8 Hours]
Principle of phase controlled converter operation- single phase full converter and semi convertersdual converters- three phase full and semi converters- reactive power- power factor improvements – extinction angle control- symmetrical angle control- PWM control- SPWM control.

UNIT-III DC-DC Converters: [9 Hours]
Study of Class – A- B- C- and D choppers- non-isolated DC-DC converters: buck- boost- buckboost converters under continuous and discontinuous conduction operation. Isolated DC-DC converters: forward- fly-back- push-pull- half-bridge- and full-bridge converters. Relationship between I/P and O/P voltages- expression for filter inductor and capacitors.

UNIT-IV Inverters: [9 Hours]
Single-phase and three-phase inverters- 1200 and 1800 modes of operation- PWM techniques: single- multiple- and sinusoidal PWM techniques- selective harmonic elimination- space vector modulation- current source inverter- multi-level inverters- techniques for reduction of harmonics.

UNIT-V Advance Techniques [5 Hours]
Advanced power conversion techniques viz resonant power conversion, multilevel converters etc.

UNIT-VI Convertor for Non-Conventional Energy Sources [5 Hours]
Power Electronics Controller for Wind Energy Electric Conversion Systems, Photo Voltaic Arrays, energy saving in AC and DC Drives.

Reference Books:

1. Power Electronics-circuits, Devices & Applications, M.H. Rashid : 3rd ed., PHI, 2005.
2. Power Electronics: Converters, Applications, Ned Mohan, T.M. Undeland, William P. Robbins:3rd ed., John Wiley & Sons, 2009

24AF2293PE103(A): MODERN CONTROL SYSTEM Credits04

Pre-Requisites: Linear control systems

Course Objectives:

Course Outcomes:

Upon successful completion of this course the student will be able to:

CO1	Analyze dynamics of a linear system by State Space Representation.
CO2	Determine the stability of a linear system using pole
CO3	Design state observers.
CO4	Analyze basics of Non-linear control system
CO5	Determine the stability of Non-linear systems.
CO6	Formulate and solve deterministic optimal control problems in terms of performance indices.

CO7	Realize the structure of a discrete time system and model its action mathematically.

Course contents:

UNIT I: STATE SPACE ANALYSIS (09 Hours)

The Concept of State and State Models, State Diagram, State Space and State Trajectory, State Space Representation using Phase Variable and Canonical Variables, Solution of State Equation, State Transition Matrix and its Properties, Eigen Values, Eigen Vectors, Model Matrix, Diagolization, Generalized Eigen vectors, Computation of State Transition Matrix using Laplace Transformation, Power Series Method, Cayley-Hamilton Method, Similarity Transformation Method. Controllability and Observability Tests: Kalman's test, Gilbert's Test, Controllability and Observability Canonical Forms.

UNIT II: POLE PLACEMENT TECHNIQUES (07 Hours)

Controller Design by State Feedback, Necessary and Sufficient Condition for Arbitrary Pole Placement-State Regulator Problem and State Regulator Design, Evaluation of State Feedback Gain Matrix K, Selection of Location of Desired Closed Loop Poles, State Observer Design, Full Order/Reduced Order Observer Design, Observer Based State Feedback Control, Separation Principle.

UNIT III: NONLINEAR CONTROL SYSTEM (10Hours)

Introduction, Properties of Nonlinear System, Behavior of Non-Linear System, Classification of Nonlinearities, Common Physical Nonlinearities: Saturation, Friction, Backlash, Dead-Zone, Relay, On-Off Nonlinearity, Nonlinear Spring, Limit cycle, Jump resonance. Phase-Plane Method, Singular points, Stability of Nonlinear System, Construction of Phase Trajectories, Describing Functions Method, Stability Analysis by Describing Function Method. Lyapunov's Stability Analysis, Lyapunov's Stability Criterion, Direct Method of Lyapunov and the Linear Systems, Method of Construction of Lyapunov Functions for Nonlinear Systems.

UNIT IV: OPTIMAL CONTROL (08 Hours)

Introduction to Optimal Control, Parameter Optimization: Servomechanism, Optimal Control Problem: Transfer Function and State Variable Approach, State Regulator Problem, Infinite Time Regulator Problem, Output Regulator and the Tracking Problem, Parameter Optimization: Regulators.

UNIT V: DIGITAL CONTROL SYSTEMS (08 Hours)

Introduction to Discrete Time Systems, Necessary for Digital Control System, Spectrum Analysis of Sampling Process, Signal Reconstruction, Difference Equations, Z transforms, and the Inverse Z transform, Pulse Transfer Function, Time Response of Sampled Data Systems, Stability using Jury Criterion, Bilinear Transformation.

Reference books:

1) Katsuhiko Ogata, Modern Control Engineering Prentice-Hall of India, New Delhi.
2) I. J. Nagarath and M. Gopal, Control system Engineering, New Age International (P) Ltd.
3) Katsuhiko Ogata, State Space Analysis of Control Systems, Prentice Hall Inc, New Jersey.
4) Benjamin C. Kuo and Farid Golnaraghi, Automatic Control Systems, 8th Edition, John Wiley & Sons.

5) H. Khalil, Nonlinear Control systems, Prentice Hall Inc, New Jersey.
6) Brogan W. L., Modern Control theory, Prentice Hall International, New Jersey.
7) Jean-Jacques E, Slotine, Weiping Li, Applied Nonlinear Control, Prentice Hall Inc., New Jersey.
8) Donald Kirk, Optimal Control Theory, an Introduction, Prentice Hall, Inc, Englewood Cliffs, New Jersey.
9) Brain D., Anderson and J. B. Moore, Optimal Control, Prentice Hall.
10)Andrew P., Sage, Optimum Systems Control, Prentice Hall.
11) M. Gopal , Digital Control & State Variable Methods, TMH.
12)A. Nagoor Kani, Control System, RBA Publications.

24AF2293PE103(B): ADVANCE TOPICS IN POWER SYSTEM Credits04

Pre-Requisites: Power system operation and analysis

Course Objectives:

This course objectives to study power system stability and reliability. To overcome the stability problem for complex and large capacity units. Classification of stability on the basis of nature of perturbation and evaluation time. In this course we will try to understand how to analyze the stability of a power system, how to improve the stability and finally how to prevent system becoming unstable.

Course Outcomes:

Upon successful completion of this course the student will be able to:

CO1	Understand facts, concepts and classification of stability on the basis of perturbation and economical aspect of energy exchange.
CO2	Analyze the characteristics of synchronous alternator under small and large disturbances.
CO3	Understand the apply knowledge of electrical subjects for solving stability problem and use method for enhancing stability
CO4	Understand and analyze the voltage stability problems and methods of improving voltage stability.
CO5	Understand and analyze the contingency issues in lines and apply the different techniques to improve it.
CO6	Understand and apply the state estimation technique for system security and load forecasting.

Course contents:

UNIT-I: [7 hours]

Generation Control Loops, AVR Loop, Performance and Response, Automatic Generation Control of Single Area and Multi Area Systems, Static and Dynamic Response of AGC Loops, Economic Dispatch and AGC.

UNIT-II: [7 hours]

Transient Stability Problem, Modeling Of Synchronous Machine, Loads, Network, Excitation and Systems, Turbine And Governing Systems, Trapezoidal Rule Of Numerical Integration

Technique For Transient Stability Analysis, Data For Transient Stability Studies, Transient Stability Enhancement Methods

UNIT-III: **[7 hours]**

Low Frequency Oscillations, Power System Model For Low Frequency Oscillation Studies, Improvement Of System Damping With Supplementary Excitation Control, Introduction To Sub Synchronous Resonance and Countermeasures.

UNIT-IV: **[7 Hours]**

Voltage Stability Problem, Real And Reactive Power Flow In Long Transmission Lines, Effect Of ULTC And Load Characteristics On Voltage Stability, Voltage Stability Limit, Voltage Stability Assessment Using PV Curves, Voltage Collapse Proximity Indices, Voltage Stability Improvement Methods.

Unit-V: **[7 Hours]**

Contingency analysis ZBUS Method in Contingency Analysis, Adding and Removing Multiple Lines, Piecewise Solution of Interconnected Systems, Analysis of Single Contingencies, Analysis of Multiple Contingencies, Contingency Analysis of DC Model, System Reduction for Contingency and Fault Studies.

Unit-VI: **[7 Hours]**

Introduction to power system security. System state classification, Load Forecasting & State Estimation: Estimation of average, periodic, stochastic components of load, basic idea of state estimation of power system. State estimation in power systems ,Security analysis.

Reference books:

1. Electric Energy System Theory: An Introduction. O.I. Elgard, .II Edition, McGraw Hill, New York, 1982.
2. Power Generation, Operation And Control., A.J. Wood, B.F. Wollenberg, .John Wiley And Sons, New York, 1984, 2nd Edition: 1996.
3. Computer Modeling Of Electrical Power Systems., J. Arrilaga, C.P. Arnold, B.J. Harker, Wiley, New York, 1983.
4. Power System Engineering, I.J. Nagrath, O.P. Kothari, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1994.
5. Electric Power System Dynamics, Yao-Nan-Yu,
6. Power System Stability and Control. P. Kundur McGraw Hill, New York, 1994.
7 Power System Dynamics, Stability and Control, K.R. Padiyar Interline Publishing (P) Ltd., Bangalore, 1999.
8. Voltage Stability of Electric Power Systems. C. Van Custem, T. Vournas, Rlever Academic Press (U.K.), 1999.
9. Power System Analysis and Design. B.R. Gupta, III Edition, A.H. Wheeler & Co. Ltd., New Delhi, 1998.
10. Reactive Power Control in Electric Power Systems. T.J.E. Miller John Wiley and Sons, New York, 1982.
8. Voltage Stability of Electric Power Systems. C. Van Custem, T. Vournas, Rlever Academic Press (U.K.), 1999.
9. Power System Analysis and Design. B.R. Gupta, III Edition, A.H. Wheeler & Co. Ltd., New Delhi, 1998.
10. Reactive Power Control in Electric Power Systems. T.J.E. Miller John Wiley and Sons, New York, 1982.

24AF2293PE103(C): RENEWABLE ENERGY SYSTEM Credits 04

Pre-Requisites: Power Plant engineering, Power system-I

Course Objective

- To introduce the new paradigm of power generation in the form of renewable energy and the various means used for power processing and optimization.
- To relate and study the various energy storage technology and their significance in the context of renewable energy based applications.

Course Outcome

Upon successful completion of this course students will be able to:

CO1	Understand current energy scenario and their impact on environment(K1 A1)
CO2	Understand the process of power generation by renewable energy sources(K1 A1)
CO3	Understand configuration of various renewable energy systems (K1 A1)
CO4	Understand various forms of energy storage and their importance (K1 A1)
CO5	Analyze the performance of grid connected system.(K2 A2)
CO6	Understand the various standards and quality issues for grid integration.

24AF2293PE103(C): RENEWABLE ENERGY SYSTEMS

Course contents:

UNIT-1: Energy Scenario [7 Hours]

Classification of Energy Sources., Energy resources (Conventional and nonconventional), Energy needs of India, and energy consumption patterns. World-wide Potentials of these sources. Energy efficiency and energy security. Energy and its environmental impacts. Global environmental concern, Kyoto Protocol, Concept of Clean Development Mechanism (COM) and Prototype Carbon Funds (PCF). Factors favoring and against renewable

UNIT-2: Solar Energy [7 Hours]

Solar thermal Systems: Types of collectors, Collection systems, efficiency calculations, applications. Photo voltaic (PV) technology: Present status, - solar cells , cell technologies, characteristics of PV systems, equivalent circuit, array design , building integrated PV system, its components, sizing and economics. Peak power operation. Standalone and grid interactive systems.

UNIT 3:-Wind Energy [7Hours]

Wind Energy: wind speed and power relation, power extracted from wind, wind distribution and wind speed predictions. Wind power systems: system components, suitability of generators, turbine rating, electrical load matching, Variable speed operation, maximum power operation, control systems, system design features, stand alone and grid connectivity, environmental impacts of wind farms.

UNIT-4: Other Energy Sources [7Hours]

Biomass - various resources, energy contents, technological advancements, conversion of biomass in other form of energy - solid, liquid and gases. Gasifiers, Biomass fired boilers, Co firing,

Municipal solid waste systems, Problems in harnessing. Hydro energy - feasibility of small, mini and micro hydel plants scheme layout economics. Tidal and wave energy - schemes, feasibility and viability. Geothermal and Ocean thermal energy conversion (OTEC) systems schemes, feasibility and viability. Fuel Cell Technology

UNIT-5: Energy storage and hybrid system configurations [7Hours]

Energy storage: Battery' - types, equivalent circuit, performance characteristics, battery design, charging and charge regulators. Battery management. Fly wheel- energy relations, components, benefits over battery. Other energy storage systems. Stand alone systems, Hybrid systems - hybrid with diesel, with fuel cell, solar-wind, wind –hydro systems, mode controller, load sharing, system sizing. Hybrid system economics.

UNIT-6 Grid Integration [7Hours]

Grid connected system and their electrical performance: Interface requirements, synchronization with grid, inrush, stable operation, load transient, safety. Operating limits of voltage, frequency, stability margin, energy storage, and IQad scheduling. Quality of power- harmonic distortion, voltage transients and sags, voltage flickers. Dynamic reactive power support.Systems stiffness. Effect of Utility restructuring.

:

References:

1. Wind and solar systems by Mukund Patel, CRC Press.
2. Solar Photovoltaics for terrestrials, Tapan Bhattacharya.
3. Wind Energy Technology - Njenkins, John Wiley & Sons,
4. Solar & Wind energy Technologies - McNeils, Frenkel, Desai, Wiley Eastern.
5. Solar Energy - S.P. Sukhatme, Tata McGraw Hill.
6. Renewable energy technologies - R. Ramesh, Narosa Publication.
7. Energy Technology - S. Rao, 'Parulkar .
8. Solar Energy - S. Bandopadhay, Universal Publishing.
9. Non-conventional Energy Systems - Mittal, Wheelers Publication

24AF2293PE103(D): ADVANCED DIGITAL SIGNAL PROCESSING Credits 04

Pre-Requisites: Power Plant engineering, Power system-I

Course Objectives:

Course Outcomes:

Upon successful completion of this course the student will be able to:

CO1	Apply digital signal processing techniques to analyze LTI systems in time and frequency domain.
CO2	2) Design and Analyze FIR digital filters
CO3	3) Design and Analyze IIR digital filters.
CO4	4) Understand and be able to implement adaptive signal processing algorithms.
CO5	Acquire the basics of multirate digital signal processing.
CO6	Explain and implement digital signal processing techniques on general purpose Digital signal processors.

Course contents:

UNIT I: DISCRETE TIME SIGNALS (08 Hours)

Introduction to Discrete time signals LTI system-stability-properties-sampling frequency domain Representation of discrete time signals and systems, discrete random signals-transforms, Properties, Inverse Z transforms.

UNIT II: DIGITAL FIR FILTER DESIGN (08 Hours)

Design of FIR filters - structures, windowing method, optimal method, Frequency sampling method.

UNIT III: DIGITAL IIR FILTER DESIGN (06 Hours)

Design of IIR filter: Impulse invariant method, Matched z-transform method, bilinear method.

UNIT IV: ADAPTIVE DIGITAL FILTERS (08 Hours)

Adaptive filters, Examples of Adaptive filtering, the minimum mean square error criterion; The Windrow and Hoff LMS Algorithm, Recursive least square Algorithm, Applications.

UNIT V: MULTI RATE DIGITAL SIGNAL PROCESSING (06 hours)

The basic sample rate Alteration Devices-Filters with sampling rate Alteration systems, Multistage Design of Decimators and Interpolators, Arbitrating rate sampling rate converter, Polyphase decomposition, digital filter design –Application.

UNIT VI: GENERAL PURPOSE DIGITAL SIGNAL PROCESSORS (06 hours)

Architecture of general purpose Digital signal processors, Implementation of DSP algorithms on general purpose processors.

Referencebooks:

1) Digital signal processing: A Practical Approach, Emmanuel C. Ifeachor, Barrie W. Jervis, Pearson Education. 2) Digital Signal Processing Principal, Algorithms and Applications, John G. Proakis, Dimitris G. Manolakis Pearson
3) Digital signal processing: A Computer Based Approach, Sanjit K. Mitra, Tata McGraw hill Pub, Company Limited New Delhi, 2001.
4) Digital signal processing, Alan Oppenheim, V and Ronals W. Schafer, Prentice Hall of India Private Limited, New Delhi, 1992.
5) Signals and systems, Simon Haylaim and Barry van veen, John wiley and sons India.
6) Digital signal processing, S,Salivahanan, Tata Mc Graw Hill Education Private Limited, New Delhi, 2010

24AF2293PE104(A): ELECTRICAL TRANSIENTS IN POWER SYSTEM Credits 04

Pre-Requisites: Electromagnetic wave theory, Power system operation and analysis

Course Outcomes:

Upon successful completion of this course the student will be able to:

CO1	Understand basic concepts of travelling wave
CO2	Understand and analyze the electrical transients and effects on transmission line
CO3	Evaluate system parameters and model the overhead lines and underground cables systems using advance digital computing tools.
CO4	Apply advance digital computing tools in evaluation of system parameters.

24AF2293PE104(A): ELECTRICAL TRANSIENTS IN POWER SYSTEM

Course contents:

UNIT-I Review Of Travelling Wave Phenomena [8 Hours]

Lumped and Distributed Parameters – Wave Equation – Reflection, Refraction, Behavior of Travelling waves at the line terminations – Lattice Diagrams – Attenuation and Distortion.

UNIT-II Lightning, Switching and Temporary Overvoltage [9 Hours]

Lightning over-voltages: interaction between lightning and power system- ground wire voltage and voltage across insulator; switching overvoltage: Short line or kilometric fault, energizing transients-closing and re-closing of lines, methods of control; temporary over-voltages: line dropping, load rejection; voltage induced by fault; very fast transient overvoltage (VFTO).

UNIT-III Parameters and Modelling of Overhead Lines [9 Hours]

Review of line parameters for simple configurations: series resistance, inductance and shunt capacitance; bundle conductors: equivalent GMR and equivalent radius; modal propagation in transmission lines: modes on multiphase transposed transmission lines, α-β-0 transformation and symmetrical components transformation, modal impedances; analysis of modes on untransposed lines; effect of ground return and skin effect; transposition schemes.

UNIT IV - Parameters of Underground Cables [8 Hours]

Distinguishing features of underground cables: technical features, electrical parameters, overhead lines versus underground cables; cable types; series impedance and shunt admittance of singlecore self-contained cables, impedance and admittance matrices for three phase system formed by three single-core self-contained cables; approximate formulas for cable parameters.

UNIT-V Computation of Power System Transients - EMTP [8 Hours]

Digital computation of line parameters: why line parameter evaluation programs? salient features of tine; constructional features of that affect transmission line parameters; elimination of ground wires bundling of conductors; principle of digital computation of transients: features and capabilities of EMTP; steady state and time step solution modules: basic solution methods.

References:

1.,Electrical Transients in Power System, Allan Green wood Wiley &Sons Inc.NewYork,1991.

2. Extra High Voltage AC Transmission Engineering, Rakosh Das Begamudre, (Second edition) Newage International (P) Ltd., New Delhi, 1990.

3. High Voltage Engineering, Naidu M S and Kamaraju V, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004.

4. EMTP Theory Book, Hermann W. Dommel, second Edition, Microtran Power System Analysis corporation, Vancouver, British Columbia, Canada, May 1992, Last Update: April 1999.

5. EMTP Literature from www.microtran.com.

24AF2293PE104(B): POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS Credits 04

Pre-Requisites: Power Electronics, Renewable energy sources.

Course objectives:-

- To use reliability theory as a tool for decision support for design, operation and planning of electric power system.

Course Outcomes:

Upon successful completion of this course the student will be able to:

CO1	Provide knowledge about the stand alone and grid connected renewable energy systems.
CO2	Equip with required skills to derive the criteria for the design of power converters for renewable energy applications.
CO3	Analyze and comprehend the various operating modes of wind electrical generators and solar energy systems.
CO4	Design different power converters namely AC to DC, DC to DC and AC to AC converters for renewable energy systems.
CO5	Develop maximum power point tracking algorithms.

ELECTIVE II: 24AF2293PE104(B): POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS

Course contents:

UNIT I: INTRODUCTION (08 Hours)

Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission) - Qualitative study of different renewable energy resources ocean, Biomass, Hydrogen energy systems: operating principles and characteristics of: Solar PV, Fuel cells, wind electrical systems-control strategy, operating area.

UNIT II: ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION (08 Hours)

Review of reference theory fundamentals-principle of operation and analysis: IG, PMSG, SCIG and DFIG.

UNIT III: POWER CONVERTERS (09 Hours)

Solar: Block diagram of solar photo voltaic system, line commutated converters,(inversion-mode) - Boost and buck-boost converters- selection of inverter, battery sizing, array sizing. Wind: three phase AC voltage controllers- AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, Grid Interactive Inverters-matrix converters.

UNIT IV: ANALYSIS OF WIND AND PV SYSTEMS (09 Hours)

Stand alone operation of fixed and variable speed wind energy conversion systems and solar system, Grid connection Issues, Grid integrated PMSG and SCIG Based WECS, Grid Integrated solar system

UNIT V: HYBRID RENEWABLE ENERGY SYSTEMS (08 Hours)

Need for Hybrid Systems- Range and type of Hybrid systems- Case studies of Wind-PV-

Maximum Power Point Tracking (MPPT).

.

References:

1) S.N.Bhadra, D. Kastha, & S. Banerjee "Wind Electricaal Systems", Oxford University Press, 2009
2) Rashid M. H. "Power Electronics Hand book", Academic press, 2001.
3) Rai G.D., "Non Conventional Energy Sources", Khanna publishers, 1993.
4) Rai. G.D.," Solar Energy Utilization", Khanna publishers, 1993.

24AF2293PE104(C): POWER ELECTRONICS AND CONTROL Credits 04

Pre-Requisites: Power Electronics, Control systems, electrical machines

Course Objectives:

1. Develop an advanced understanding of power electronic converter topologies and their dynamic modeling.
2. Explore control strategies for power converters interfacing with electric drives and renewable energy systems.
3. Understand the interaction between electrical machines and power electronic converters under various control schemes.
4. Apply digital control and modern intelligent control methods to power electronics-based systems.
5. Foster simulation and hardware-in-the-loop (HIL) experimentation skills.

Course outcomes:

Upon successful completion of this course the student will be able to:

CO1	Develop mathematical models for power converters and electrical drives.
CO2	Design advanced feedback control strategies for converters and drives.
CO3	Implement and validate control algorithms on digital platforms like DSPs, FPGAs, or microcontrollers.
CO4	Analyze the impact of power electronics control in smart grid and renewable energy scenarios.
CO5	Simulate and interpret dynamic performance of complex electromechanical systems.

Course Contents:

UNIT-I: Advanced Power Converter Topologies (7 Hrs)

Review of switched-mode converters, Resonant and soft-switching converters, Multilevel inverters (NPC, flying capacitor, cascaded H-bridge), Matrix converters

UNIT-II: Modeling and Control of DC-DC Converters (10 Hrs)

Averaged and small-signal models, State-space modeling, Current-mode and voltage-mode control,Digital control of converters

DC-AC Inverters and Control : SPWM, SVPWM, and space vector theory, Grid-tied inverter control (synchronous and droop-based), Harmonic analysis and filtering

UNIT-III: Electrical Machine Drive Systems (7 Hrs)

DC motor and brushless DC motor drives, Induction motor control (scalar and vector),Field-Oriented Control (FOC), Direct Torque Control (DTC),PMSM control

UNIT-IV: Digital and Intelligent Control Techniques (7 Hrs)

Digital implementation of PI/PID control, Sliding Mode Control (SMC),Model Predictive Control (MPC),Fuzzy logic and neural networks in control

UNIT-V: Case Studies and Industry Applications (10 Hrs)

Electric vehicle drive systems, HVDC transmission, Smart grid interfacing of distributed generation.

Renewable Energy Integration

MPPT algorithms for PV and wind, Interfacing converters for hybrid energy systems,Grid synchronization, islanding detection

UNIT-VI: Laboratory and Simulation Work

MATLAB/ Simulink modeling of converters and drives,Hardware-in-the-loop (HIL) experiments using dSPACE, TI DSP, or STM32,Controller implementation for real-time motor control

TEXTBOOKS:

1. **Mohammed H. Rashid**, *Power Electronics: Circuits, Devices and Applications*, Pearson.
2. **Ned Mohan**, *Power Electronics: Converters, Applications, and Design*, Wiley.
3. **Bimal K. Bose**, *Modern Power Electronics and AC Drives*, Prentice Hall.
4. **R. Krishnan**, *Electric Motor Drives: Modeling, Analysis, and Control*, Prentice Hall.
5. **Erickson & Maksimovic**, *Fundamentals of Power Electronics*, Springer.
6. **Leonhard W.**, *Control of Electrical Drives*, Springer.
7. **Rashid M.H.**, *Simulation of Power Electronic Circuits Using MATLAB/Simulink*, CRC Press.
8. IEEE Transactions on Power Electronics, Industrial Electronics, Smart Grid, and Control Systems.
9. Application notes from Texas Instruments, Infineon, STMicroelectronics, and NXP.

23U2612OE105	Research Methodology	Credits04

Course Objectives:

1. To develop a research orientation among the scholars and to acquaint them with fundamentals of research methods.
2. To develop understanding of the basic framework of research process.
3. To identify various sources of information for literature review and data collection.
4. To understand the components of scholarly writing and evaluate its quality.

Course Outcomes:

1. Learner will learn the meaning ,objective ,motivation, and type of research
2. Learner will be able to formulate their research work with the help of literature review
3. Learner will be able to develop an understanding of various research design and techniques
4. Learner will have overview knowledge of modeling and simulation of research work
5. Learner will be able to collect the statistical data with different methods related to research work
6. Learner will be able to write their own research work with ethics and non-plagiarized way.

Course content:

UNIT I
Introduction: Defining research, Motivation and Course Objectives, Types of research Meaning of Research, Course Objectives: of Research, Motivation in Research, Types of Research.

UNIT II
Research Formulation: Formulating the research Problem, Literature Review, Development of Working Hypothesis.

UNIT III
Research Design: Important Concept in Research Design, Research Life Cycle, Developing Research Plan.

UNIT IV
Overview of Modelling and Simulation: Classification of models, Development of Models,Experimentation,Simulation.

UNIT V
Statistical Aspects: Methods of Data Collection, Sampling Methods, Statistical analysis, Hypothesis testing.

UNIT VI
Research Report: Research Ethics, Plagiarism, Research Proposal, Report Writing and Writing Research Papers.

Textbooks/References:

1. J.P.Holman., Experimental Methods for Engineers.
2. C.R.Kothari, Research Methodology, Methods &Techniques.

23U2901PCL106	PG-LAB-1	Credits 04

Objective: To develop the analytical and practical skills in the students.

Course Outcomes:
Upon successful completion of this LAB-I the student will be able to:

CO1	Apply the knowledge to design the practical circuits for applications.
CO2	Model and simulate different electrical and electronics systems
CO3	Simulate and test the circuit performance for comparative study.

The PG lab -1 will be comprising of at least TWO experiments from each of the subjects such as representation of Power System Elements like Synchronous machines, transformers, transmission lines, loads, power system load flow, short circuit studies and power system stability studies using MATLAB-SIMULINK, PSCAD, CAPS software. Study of power semiconductor devices, study AC to DC, DC to DC converter circuits etc using software, design as well as by building up the circuits in laboratories. Renewable energy systems.

23U2901AU108	Yoga for Stress Management	Audit Course

Course Objectives:

1. Understand the physiological and psychological aspects of stress and its impact on overall well-being.
2. Learn and practice specific yoga postures, breathing exercises, and relaxation techniques to alleviate stress.
3. Explore the connection between mindfulness, meditation, and stress reduction, fostering mental clarity.
4. Discover holistic practices that promote better sleep, nutrition, and overall lifestyle habits for stress management.
5. Develop practical skills to manage stress in daily life, enhancing resilience and promoting emotional balance.

Course Outcomes:

1. Recognize the signs and sources of stress, understanding its effects on mental and physical well-being.
2. Master a variety of yoga techniques, including postures, breathing, and meditation, to effectively manage stress.
3. Acquire relaxation strategies that promote calmness, reduce anxiety, and enhance overall mental clarity.
4. Incorporate healthy habits inspired by yoga principles to foster better sleep, nutrition, and self-care routines.
5. Develop practical skills to navigate and cope with stress, enhancing emotional balance and promoting a more harmonious life.

Course content:

UNIT I

Introduction to Yoga for Stress Management - 1Introduction to Yoga for Stress Management – 2.Stress according to Western perspective, Stress Eastern Perspective
Developmental process: Western and Eastern Perspective Stress Hazards and Yoga

UNIT II

Meeting the challenges of Stress – 1.Meeting the challenges of Stress
2 Introduction to Stress Physiology, Stress, Appetite and Dietary management
3. Modern and Yogic perspective, Sleep and Stress: understanding the relationship for effective management of stress

UNIT III

Stress Assessment methods-a valuable tool toward stress management
Role of Yoga in prevention and management of stress related disorders – a summary of research evidence
Concept of stress and its management - perspectives from Patanjali Yoga Sutra - Part 1
Concept of stress and its management - perspectives from Patanjali Yoga Sutra - Part 2
Concept of stress and its management-perspectives from Patanjali Yoga Sutra -Part3

UNIT IV

Concept of stress and its management - perspectives from Bhagavad Gita - Part 1
Concept of stress and its management - perspectives from Bhagavad Gita - Part 2
Concept of stress and its management –perspectives from BhagavadGita - Part3

UNITV

Bio-Psycho-Socio-Spiritual model of stress management Yoga practices for Stress
Breathing practices–1
Hands in and out breathing, Hands stretch breathing, Ankle stretch breathing
Breathing practices– 2
Dog Breathing, Rabbit breathing, Tiger breathing, Sashankasana breathing
Breathing practices– 3
Bhujangasana breathing, Ardha Shalabhasana breathing (alternate legs), Straight leg raising (alternate legs),Straight leg raising(both legs),Sethubandhasanalumbar stretch, Instant Relaxation Technique(IRT)
Loosening Practices–1
Shoulder Rotation, Side bending, standing twist, Hip rotation, Thigh strengthening
Loosening practices – 2
Chakkichalan, BhunamasanaChalana, Alternative toe touching
Looseningpractices – 3
Side leg raising, Pavanamuktasanakriya: Wind releasing pose movements, Quick Relaxation Technique (QRT)

UNIT VI

Asana practices–1
Tadasana,ArdhakatiChakrasana,ArdhaChakrasana,Trikonasana,Vrikshasana
Asana practices – 2
Vakarasana, JanuSirshasana, Ushtrasana, Sashankasana,
Asana practices – 3
Ardhamatseyndrasana, Paschimottanasana, Poorvottanasana, Gomukhasana

Asana practices – 4
Makarasana, Bhujangasana, SalambhaShalabahasana, Dhanurasana
Asana practices – 5
Setubandhasana, Sarvangasana, Mastyasana, Deep Relaxation Technique (DRT) Soorya Namaskar
Pranayama–1
Kapalbhartikriya and Sectional Breathing
Pranayama– 2
Nadishuddhi Pranayama
Pranayama– 3
Bhramari, Sheetali, Sitkari and Ujjayi Om Meditation, Cyclic Meditation
Integrated Yoga Module I
Integrated Yoga Module II
Integrated Yoga Module III

Textbooks/References:

1. H R Nagendra and R Nagarathna. Yoga for Promotion of Positive Health.Swami Vivekananda Yoga Prakashana. 2011.
2. Contrada, R., & Baum, A. (Eds.). The handbook of stress science:Biology,psychology,and health.SpringerPublishing Company. 2010
3. Al'Absi, M. (Ed.). Stress and addiction: Biological and psychological mechanisms.Elsevier.2011.
4. Van den Bergh, O. Principles, and practice of stress management. Guilford Publications.2021.
5. Swami Muktibodhananda,Hatha Yoga Pradipika,Bihar School of Yoga,1998
6. Swami Satyananda Saraswati,Four Chapters on Freedom, Bihar School ofYoga,1975
7. Swami Tapasyananda,Srimad BhagavatGita,Sri Ramakrishna Math,2012

SEMESTERII

24AF2293PC201:	AC/ DC DRIVES	Credits 04

Pre Requisites: Power Electronics, electrical machines

Course Objective

Course Outcome

Upon successful completion of this course the student will be able to:

CO1	Explain the basics of Electrical Drives.
CO2	Develop the closed loop controlled DC drives.
CO3	Describe the modern trends of DC Dives.
CO4	Explain the basics methods of speed control of Induction motor.
CO5	Apply the various speed control methods for controlling the speed of Induction motor.
CO6	Apply the various speed control methods for controlling the speed of synchronous motor.
CO7	Use vector control method for controlling the Induction motor drive.

24AF2293PC201: AC/ DC DRIVES

Course Contents:

UNIT

UNIT I: INTRODUCTION
(03 Hours)

Electrical Drives, advantages, elements of drive system, drive characteristics, criteria for selection of drive components, dynamics of D.C. motor drives, steady-state stability.

UNIT II: D.C. DRIVES **(09 Hours)**

Introduction, principle of DC motor speed control, phase controlled converters, steady state analysis of three phase converter controlled DC motor Drive, two quadrant three phase controlled DC drive. Introduction, Principle of operation of the chopper, Chopper controlled drives, Duty-ratio control, current-limit control, steady state analysis, four quadrant chopper circuit, chopper for inversion, chopper with other power devices, mode of chopper, input to the chopper, steady state analysis of chopper controlled DC Drives, pulsating torques, DC motor Drive with field weakening, four quadrant DC motor drives, converter selection and characteristics

UNIT III: CLOSED-LOOP CONTROL OF DRIVES **(08 Hours)**

Introduction- Basic features of an Electric Drive- Block diagram representation of Drive systems, signal flow graph representation of the systems, Transfer functions, transient response of closed loop drives systems. Speed control of a separately excited DC drive with inner current loop and outer speed loop,

UNIT IV: SPEED CONTROL OF INDUCTION MOTOR **(10 Hours)**

Principles of speed control, Various methods of Induction motor drive, Variable voltage operation, Variable frequency operation, Constant flux operation, Torque-Slip characteristic, Constant Torque and Constant power operation, Implementation of V/f control with slip

compensation scheme Speed control of VSI and CSI fed drives - design examples. Closed loop control schemes - dynamic and regenerative braking - speed reversal. Torque slip characteristics- speed control through slip - rotor resistance control- chopper controlled resistance equivalent resistance combined stator voltage control and rotor resistance control- design solutions. Closed loop control scheme. Slip power recovery - torque slip characteristics - power factor considerations.

UNIT V: VECTOR CONTROL OF INDUCTION MOTOR DRIVE (07 Hours)

Review of dq0 model of 3-Ph IM, Principle of vector control of IM - Direct vector control – Indirect vector control with feedback - Indirect vector control with feed-forward - Indirect vector control in various frames of reference, Decoupling of vector control with feed forward compensation – Direct Torque Control of IM

UNIT VI: SPEED CONTROL OF SYNCHRONOUS MOTOR DRIVES (09Hours)

Three phase synchronous machine and analysis of steady state operation - voltage and torque equations in machine variables and rotor reference frame variables (Park's equations) – analysis of dynamic performance for load torque variations.

Types of PM Synchronous motors - Torque developed by PMSM - Model of PMSM – Implementation of vector control for PMSM

References:

1) G.K.Dubey, Power Semi conductor controlled Drives, New Age Int. Pub.
2) S.B.Dewan, G.R.Slemon & A.Stranghan, Power Semi conductor controlled Drives, John wiley Pub.
3) Shepherd Hullay & Liag, Power Electronics & Motor Control: Cambridge Univ. Press
4) R.Krishnan, Electric Motor drives – Modelling, Analysis & Control: PHI India, Ltd.
5) Vedam Subramanyam, Thyristor Control of Electric Drives.
6) Vector Control of AC Drives, I. Boldea and S. A. Nasar, CRC Press LLC, 1992.

24AF2293PC202: ADVANCED POWER SYSTEM PROTECTION Credits 04

Pre-Requisites: Switchgear and Protection

Course Objectives:-

- To understand various Optimization Techniques applicable in Power System and Optimal Power flow solution methods.
- To understand the concept of power System Security.
- To apply state estimation in power system.

Course Outcomes:-

Upon successful completion of this course the student will be able to:

CO1	Understand philosophy of various relays used in power system protection.
CO2	Understand basic principle of digital relaying.

24AF2293PC202 ADVANCED POWER SYSTEM PROTECTION

Course content:

UNIT-I: Static Relays **[9 Hours]**

Advantages of static relays-Basic construction of static relays-Level detectors-Replica impedance–Mixing circuits-General equation for two input phase and amplitude comparators-Duality between amplitude and phase comparators. AMPLITUDE COMPARATORS: Circulating current type and opposed voltage type- rectifier bridge comparators, Direct and Instantaneous comparators.

UNIT-II: Phase Comparators **[8 Hours]**

Coincidence circuit type- block spike phase comparator, techniques to measure the period of coincidence-Integrating type-Rectifier and Vector product type- Phase comparators. STATIC OVER CURRENT RELAYS: Instantaneous over-current relay-Time over-current relays basic principles –definite time and Inverse definite time over-current relays.

UNIT-III: Static Differential Relays **[9 Hours]**

Analysis of Static Differential Relays –Static Relay schemes –Duo bias transformer differential protection –Harmonic restraint relay. STATIC DISTANCE RELAYS: Static impedance reactance–MHO and angle impedance relay sampling comparator –realization of reactance and MHO relay using sampling comparator.

UNIT-IV: Multi-Input Comparators **[8 Hours]**

Conic section characteristics-Three input amplitude comparator –Hybrid comparator-switched distance schemes –Poly phase distance schemes- phase fault scheme –three phase scheme –combined and ground fault scheme. POWER SWINGS: Effect of power swings on the performance of distance relays –Power swing analysis-Principle of out of step tripping and blocking relays-effect of line and length and source impedance on distance relays.

UNIT-V: Microprocessor Based Protective Relays **[8 Hours]**

(Block diagram and flowchart approach only)-Over current relays–impedance relays-directional relay-reactance relay .Generalized mathematical expressions for distance relays-measurement of resistance and reactance –MHO and offset MHO relays-Realization of MHO characteristics-Realization of offset MHO characteristics -Basic principle of Digital computer relaying.

References Books:

1. Power system protection and Switch gear ,Badri Ram and D.N.Vishwakarma, “TMH publication New Delhi 1995.

REFERENCES:

1 Static relays, T.S.Madhava Rao, TMH publication, second edition 1989.
2. Protection and Switchgear, Bhavesh Bhalja, R. P. Maheshwari, Nilesh G. Chothani, Oxford University Press.
3. Electrical Power System Protection, C. Christopoulos and A. Wright, Springer International.

24AF2293PC203(A): POWER SECTOR ECONOMICS,RESTRUCTURING & REGULATION Credits 03

Pre-Requisites: Power plant engineering, power systems

Course Objectives:-To understand national policy in power system restructuring

Course Outcomes:-

Upon successful completion of this course the student will be able to:

CO1	Understand power sector scenario in India.

CO2	Understand the national policy, economics and regulation.
CO3	Understand the power sector restructuring and market reforms.
CO4	Understand the transmission planning and pricing techniques.

24AF2293PC203(A): POWER SECTOR ECONOMICS,RESTRUCTURING & REGULATION

Course content:

UNIT-I:

UNIT-I: Power Sector in India [7 Hours]
Introduction to various institutions in an Indian Power sector such as CEA, Planning Commissions, PGCIL, PFC, Ministry of Power, state and central governments, REC, utilities and their roles. Critical issues challenges before the Indian power sector, Salient features of Electricity act 2003, various national policies and guidelines under this act.

UNIT-II: Power sector economics and regulation [7 Hours]
Typical cost components and cost structure of the power sector, Different methods of comparing investment options, Concept of life cycle cost , annual rate of return , methods of calculations of Internal Rate of Return (IRR) and Net Present Value (NPV) of project, Short term and long term marginal costs, Different financing options for the power sector. Different stakeholders in the power sector, Role of regulation and evolution of regulatory commission in India, types and methods of economic regulation, regulatory process in India.

UNIT-III: Power Tariff [7 Hours]
Different tariff principles (marginal cost, cost to serve, average cost), Consumer tariff structures and considerations, different consumer categories, telescopic tariff, fixed and variable charges, time of day, interruptible tariff, different tariff based penalties and incentives etc., Subsidy and cross subsidy, life line tariff, Comparison of different tariff structures for different load patterns etc.

UNIT-IV: Power sector restructuring and market reform [7 Hours]
Different industry structures and ownership models Competition in the electricity sector conditions, barriers, different types, benefits and challenges etc. Different market and trading models arrangements, key market entities- ISO, Genco, Transco, Disco, Retail co, Power market types, Energy market, ancillary service market, transmission market, Forward and real time markets, market power.

UNIT-V: Electricity Markets Pricing and Non-price issues [7 Hours]
Electricity price basics, Market Clearing price (MCP), Zonal and locational MCPs. Dynamic, spot pricing and real time pricing, Dispatch based pricing, Power flows and prices, Optimal power flow Spot prices for real and reactive power. Unconstrained real spot prices, constrains and real spot prices. Non price issues in electricity restructuring (quality of supply and service, environmental and social considerations) Global experience with electricity reforms in different countries.

UNIT-VI: Transmission Planning and pricing [7 Hours]
Transmission planning, Different methods of transmission pricing, Different transmission services, Congestion issues and management, Transmission cost allocation methods, Locational marginal price, firm transmission right. Transmission ownership and control, Transco and ISO, Transmission pricing Model in India, Availability based tariff, role of load

dispatch centers (LDCs) Salient features of Electricity act 2003, Price based Unit commitment, concept of arbitrage in Electricity markets, game theory methods in Power System, and security constrained unit commitment. Ancillary services for restructuring, forward ancillary service auction

References Books:

1. Regulation in infrastructure SeNices: Progress and the way forward - TERI, 2001
2. Paper "The real challenges in Power sector Restructuring: Instilling Public Control Through TApn, Prayas Energy Group, Energy for Sustainable Development, September 2001, www.DravaSDune.org
3. Privatization or Democratization The Key to the Crises in the Electricity Sector - The Case of Maharashtra 2002, www.prayaspune.org
4. Maharashtra Electricity Regulatory Commission Regulations and Orders – www.mercindia.com
5. Various publications, reports and presentations by Prayas, Energy Group, Pune
6. Central Electricity Regulatory Commission, Regulations and Orders - www.cercind.ora
7. Electricity Act 2003 and National Policies - www.Dowermin.nic.in
8. Sally Hunt, "Making Competition Work in Electricity, 2002, John Wiley Inc
9. Electric Utility Planning and Regulation, Edward Kahn, American Council for Energy Efficient Economy
10. Market Operations in Electric Power Systems Forecasting, Scheduling and Risk Management

Pre-Requisites: Power plant engineering, Power system operation and control

24AF2293PC203(B): DISTRIBUTED GENERATION & MICROGRID 03Credits

Course Objectives:-

To understand various aspects of smart grid design to meet the needs of a utility viz Meeting a utility's objectives, Helping to adopt new technologies in to the grid, Creating a framework for knowledgeable power engineers to operate the grid more effectively and to address the issues and challenges that remain to be solved.

Course Outcomes:

Upon successful completion of this course the student will be able to:

CO1	Understand exploration of renewable energy sources
CO2	Understand philosophy of distributed generation
CO3	Understand various issues of DG with grid integration
CO4	Understand the concept of micro grid and various power quality issues.

ELECTIVE III: 24AF2293PC203 (B): DISTRIBUTED GENERATION & MICROGRID

Course contents:

UNIT I – INTRODUCTION (9 hours)

Conventional power generation: advantages and disadvantages, Energy crises, Non-conventional energy(NCE) resources: review of Solar PV, Wind Energy systems, Fuel Cells, micro-turbines, biomass, and tidal sources.

UNIT II – DISTRIBUTED GENERATIONS (DG) (9 hours)

Concept of distributed generations, topologies, selection of sources, regulatory standards/ framework, Standards for interconnecting Distributed resources to electric power systems: IEEE 1547. DG installation classes, security issues in DG implementations. Energy storage elements: Batteries, ultra-capacitors, flywheels. Captive power plants.

UNIT III – IMPACT OF GRID INTEGRATION (9 hours)

Requirements for grid interconnection, limits on operational parameters,: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues.

UNIT IV- MICROGRIDS (10 hours)

Concept and definition of microgrid, microgrid drivers and benefits, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC microgrids, Power Electronics interfaces in DC and AC microgrids, communication infrastructure, modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques.

UNIT V- POWER QUALITY ISSUES IN MICROGRIDS (5 hours)

Power quality issues in microgrids- Modelling and Stability analysis of Microgrid, regulatory standards, Microgrid economics, Introduction to smart microgrids.

.

References Books:-

1. Voltage Source Converters in Power Systems: Modeling, Control and Applications, Amir naser Yezdani, and Reza Iravani, IEEE John Wiley Publications,2009.
2. Power Switching Converters: Medium and High Power, Dorin Neacsu, CRC Press, Taylor & Francis,2006.
3. Solar Photo Voltaics, Chetan Singh Solanki, PHI learning Pvt. Ltd., New Delhi,2009.
4. Wind Energy Explained, theory design and applications, J.F. Manwell, J.G. McGowan Wiley publication,2002.
5.Biomass Regenerable Energy, D. D. Hall and R. P. Grover, John Wiley, New York, 1987.
6.Renewable Energy Resources, John Twidell and Tony Weir, Tyalor and Francis Publications, 2005.
7.SmartGrid:TechnologyandApplications,JanakaEkanayake,NickJenkins,Kit siri Liyana ge, JianzhongWu,AkihikoYokoyama,JohnWiley&sonsinc,2012.
8. SmartGrid: Integrating Renewable, Distributed & Efficient Energy, Fereidoon P.Sioshansi,AcademicPress,2012.
9. The smart grid: Enabling energy efficiency and demand response, ClarkW.Gellings, Fairmont Press Inc,2009.

24AF2293PC203(C): EMBEDDED SYSTEMS Credits 03

CCourse Objectives:-

Course Outcomes:

Upon successful completion of this course the student will be able to:

CO1	Define and explain embedded systems and the different embedded system design technologies explain the various metrics or challenges in designing an embedded system
CO2	Become aware of the architecture of the ARM processor and its programming aspects(assembly Level)
CO3	Foster ability to understand the internal architecture Processor LPC 2148
CO4	Understand key concepts of embedded systems like IO, timers, interrupts, interaction with peripheral devices
CO5	Design real time embedded systems using the concepts of RTOS.
CO6	Analyze various examples of embedded systems based on ARM processor.

Coursecontent:

UNIT I–

UNIT I: INTRODUCTION TO EMBEDDED SYSTEMS (08 Hours)

Introduction to embedded system -Definition and Classification, Design challenges, Optimizing design metrics, time to market, applications of embedded systems and recent trends in embedded systems, memory management, Overview of Processors and hardware units in an embedded system, Software embedded into the system, communication protocols like SPI, I2C, CAN etc.

UNIT II: ARCHITECTURE OF ARM7TDMI (05 Hours)

Introduction to ARM core architecture, ARM extension, family, Pipeline, memory management, Bus architecture, Programming model, Registers, Operating modes, instruction set, Addressing modes, memory interface.

UNIT III: ON CHIP PERIPHERALS AND INTERFACING LPC2148 (08 Hours)

Study of on-chip peripherals – Input/ output ports, Timers, Interrupts, on-chip ADC, DAC, RTC modules, WDT,PLL, PWM,USB, I2C, SPI, CAN etc.

UNIT IV: INTERFACING WITH LPC2148 (08 Hours)

Need of interfacing, interfacing techniques, interfacing of different displays including Graphic LCD,controlling a DC motor using PWM, Keypad controllers, stepper motor controllers.

UNIT V: REAL TIME OPERATING SYSTEMS (08 Hours)

Definitions of process, tasks and threads, I/O Subsystems, Interrupt Routines Handling in RTOS, RTOS Task scheduling models, Handling of task scheduling and latency and deadlines as performance metrics, Co-operative Round Robin Scheduling, Case Studies of Programming with RTOS.

UNIT VI: INTRODUCTION TO ARM 9 (05 Hours)

ARM926EJ-S, Features, Specifications (LPC314x /LPC315x As reference controllers)

REFERENCES BOOS:

1) Embedded Systems Architecture, Programming and Design, Rajkamal, TATA McGraw-Hill, First reprint Oct, 2003.
2) Embedded Systems Design, Second Edition, Steve Heath, Elsevier India Pvt. Ltd. 2007.
3) Andrew Sloss, Andew Sloss, "ARM System Developers Guide"
4) Introduction to Embedded systems, Shibu K V, Tata McGraw Hill First print – 2009.
5) An Embedded Software Primer, David E,Simon, Pearson Education Asia, 2000.
6) Embedded Systems Design, A unified Hardware /Software Introduction, Frank Vahid and Tony Givargis, John Wiley, 2002.

24AF2293OE204 OPEN ELECTIVE I Credits 03

Couse Code	NPTEL Course	Credits	Name of Instructor	HostInstitute	Link
24AF2293OE204A	New Labour Codes of India	3	Prof.KDRaju	IIT Kharagpur	https://onlinecourses.nptel.ac.in/noc23_lw05/preview
24AF2293OE204B	Urban Utilities Planning: Water Supply, Sanitation and Drainage	3	Prof. Debapratim Pandit	IIT Kharagpur	https://onlinecourses.nptel.ac.in/noc23_ar08/preview
24AF2293OE204C	Environment and Development	3	Prof. NgamjahaoKipgen	IIT Guwahati	https://onlinecourses.nptel.ac.in/noc21_hs83/preview
24AF2293OE204D	Entrepreneurship	3	Prof. C Bhaktavatsala Rao	IITMadras	https://onlinecourses.nptel.ac.in/noc20_mg35/preview

24AF2293OE205 INTELLECTUAL PROPERTY & RIGHTS Credits03

Course Objectives:-

1. Introduce the concept, types, and importance of Intellectual Property Rights (IPR).
2. Familiarize students with the processes involved in protecting intellectual property, especially patents.
3. Encourage awareness about legal and ethical issues in research, innovation, and commercialization.
4. Highlight the role of IPR in engineering domains such as electrical systems, embedded technologies, and electronics.
5. Equip students with the knowledge required to file patents and avoid infringement in academic and industrial research.

Course Outcomes:

Upon successful completion of this course the student will be able to:

CO1	Understand various forms of intellectual property including patents, copyrights, trademarks, and trade secrets.
CO2	Apply IP knowledge in research, product development, and technology transfer.
CO3	Navigate the Indian and international IP filing systems, particularly related to patents.
CO4	Identify potential IP in their research work and understand how to safeguard it.
CO5	Comprehend the ethical and legal aspects of IP infringement and licensing.

Course content:

UNIT I: Introduction to Intellectual Property (07 Hours)

Definition, importance, and types of IP**,** Need for protection of IP**,**IPR and its impact on research and development**,** Role of IPR in academia and industry

UNIT II: Patents – Principles and Filing Process (07 Hours)

Basics of patents: criteria, types, and scope**,** Patentability of electrical and electronic inventions**,** Patent filing process: India and international (WIPO, PCT)**,**Patent search, patent specification, and drafting

UNIT III: Copyrights and Trademarks (10 Hours)

Concept of copyright and fair use**,** Copyright in software and publications**,** Trademark: definitions, symbols, and registration process**,** Case studies relevant to electrical and computer engineering

Design and Trade Secrets : Industrial designs, Trade secrets: protection and enforcement, Relevance in product and circuit designs

UNIT IV: IP Laws and Organizations (07 Hours)

Indian IPR system and regulatory framework, International IPR treaties and conventions (TRIPS, WIPO, WTO),Role of IP offices in India and abroad

UNIT V: Case Studies in Engineering and Technology (07 Hours)

IP issues in embedded systems, electrical design, and AI, Case studies: Patent infringement and disputes, Technology licensing and commercialization

UNIT VI: Ethics, IP Management and Innovation (07 Hours)

Ethics and responsibilities in research and publishing, IP management in academic institutions and R&D labs, Startups, incubation, and IP commercialization strategies

REFERENCES BOOKS:

1. **N.S. Gopalakrishnan and T.G. Agitha**, *Principles of Intellectual Property*, Eastern Book Company.
2. **P. Narayanan**, *Intellectual Property Law*, Eastern Law House.
3. **Prabuddha Ganguli**, *Intellectual Property Rights: Unleashing the Knowledge Economy*, Tata McGraw Hill.
4. **Cornish, Llewelyn & Aplin**, *Intellectual Property: Patents, Copyrights, Trademarks & Allied Rights*, Sweet & Maxwell.
5. **WIPO** (World Intellectual Property Organization): https://www.wipo.int
6. **Indian Patent Office**: https://www.ipindia.gov.in
7. Research papers, court judgments, and recent case studies from IEEE, Elsevier, and IPR-related journals.

24AF2293PCL206	PG-LAB-II	Credits04

Students are instructed to frame and perform laboratory assignment/experiments based on each of theory Course. The assignment should encompass the hardware and engineering computation software such as MATLAB, PSCAD, ETAP etc. techniques/tools introduced the concerned subjects and shoul prove to be useful for the PG program in the relevant field with moderate to high complexity. Assignment should be a full-fledged system design problems with multidimensional solutions suggested.

24AF2293PCL207	SEMINAR-I

Seminar-I shall be on state of the art topic of student's own choice based on relevant specialization approved by an authority. Student should deliver seminar on the state of the art topic in front of the external examiners/internal examiners, staff and student colleagues Prior to presentation student should carry the details of literature survey form standard references such as international journals and periodicals, recently published reference books etc. The student shall submit the duly certified seminar report in standard format, for satisfactory completion of the work by the concerned Guide and Head of the department/institute. The assessment shall be based on selection of topic its relevance to present context, report documentation and presentation skills.

24AF2293IK208	IKSBucket#	Credits02

Couse Code	NPTEL Course	Credits	Name ofInstructor	HostInstitute	Link
24AF2293IK208A	Indian Knowledge System (IKS):Concepts and Applications in Engineering	4	Prof.B.Mahadevan, Dr.Vinayak Rajat Bhat,Dr. R VenkataRaghavan	Prof. B.Mahadevan, Dr. Vinayak Rajat Bhat, Dr.R VenkataRaghavan	https://onlinecourses.swayam2.ac.in/imb23_mg53/preview
24AF2293IK208B	Indian Knowledge System (IK):Humanities and Social Sciences	4	Prof.B.Mahadevan, Dr.Vinayak Rajat Bhat,Dr. R VenkataRaghavan	Indian Institute of Management Bangalore(IIMB) ,Chanakya University, Bangalore	https://onlinecourses.swayam2.ac.in/imb23_mg55/preview
24AF2293IK208C	Ancient Indian Management	2	Dr. Alka Jain	Taxila Business School	https://onlinecourses.swayam2.ac.in/aic22_ge19/preview

24AF2293AU209	DISASTER MANAGEMENT	Credits02

SEMESTERIII

24AF2293PE301(A) APPLICATION OF POWER ELECTRONICS TO POWER SYSTEMS

Credits02

Course Objectives:-

- To know the basic principle of conventional active and reactive power flow control in power systems and problems associated with long distance power transmission.
- To make students aware how power electronics devices can be used to find solution to the problems in long distance power transmission.

Course Outcomes:

Upon successful completion of this course the student will be able to:

CO1	Understand the concept of FACTs
CO2	Select and implement proper compensator to solve the problems occurring power transmission
CO3	Model and analyze the FACT controllers
CO4	Understand and apply the active filtering techniques in mitigation of harmonic distortion.

Course contents:

Unit1 **[5 hrs]**

Review of semiconductor devices, Steady state and dynamic problems in AC systems, Power flow

Unit 2 **[6 hrs]**

Flexible AC transmission systems (FACTS): Basic realities & roles, Types of facts controller, Principles of series and shunt compensation.

Unit 3 **[9 hrs]**

Description of static var compensators (SVC), Thyristor Controlled series compensators (TCSC), Static phase shifters (SPS), Static condenser (STATCON), Static synchronous series compensator (SSSC) and Unified power flow controller (UPFC).

Unit 4 **[8 hrs]**

Modelling and Analysis of FACTS controllers. Control strategies to improve system stability. Power Quality problems in distribution systems.

Unit 5 **[7 hrs]**

Harmonics, harmonics creating loads, modelling, Series and parallel resonances, harmonic power flow,Mitigation of harmonics, filters, passive filters.

Unit 6 **[5 hrs]**

Active filters, shunt, series hybrid filters, voltage sags & swells, voltage flicker. Mitigation of power quality problems using power electronic conditioners. IEEE standards.

References Books:

1. Understanding of FACTs., Hingorani, N. G.; IEEE Press 1996.
2. Power Quality.; Heydt G.T.; Stars in a Circle Pblications , Indiana, 1991.
3. Static Reactive Power Compensation.; Miller T.J.E.; John Wiley & Sons, New York, 1982
4. Flexible AC Transmission System. (FACTs).; Yong Hua Song.; IEE 1999.
5. Recent Publications on IEEE Journals.

24AF2293PE301(B) ELECTRIC AND HYBRID VEHICLES Credits03

Course Objectives:-

Course Outcomes:

Upon successful completion of this course the student will be able to:

CO1	Describe the configuration and performance of Electric vehicles
CO2	Design the structure of Hybrid Electric Vehicle
CO3	Describe the operation of Fuel Cells
CO4	Explain Electric propulsion system and Motor control systems
CO5	Discuss energy storage devices and generators

Course contents:

UNIT.1.

UNIT I ELECTRIC VEHICLES (08 Hours)

Introduction, Layout of an Electric Vehicle, Performance of Electric Vehicles a) Traction Motor Characteristics b) Tractive Effort and Transmission Requirements c) Vehicle Performance , Energy Consumption, Advantages and Limitations, Specifications, System Components, Electronic Control System.

UNIT II: HYBRID VEHICLES (08 Hours)

Concepts of Hybrid Electric Drive Train, Architectures of Series Hybrid Electric Drive Trains, Architectures of Parallel Hybrid Electric Drive Trains, Merits and Demerits, Series Hybrid Electric Drive Train Design, Parallel Hybrid Electric Drive Train Design.

UNIT III: FUEL CELLS & SOLAR CARS (08 Hours)

Photovoltaic Cells, Tracking, Efficiency, Solar Cars, Fuel Cells - Construction & Working, Equations, Possible Fuel Sources, Fuel Reformer, Design, Cost Comparison.

UNIT IV: ELECTRIC PROPULSION SYSTEM AND MOTOR CONTROL SYSTEM (10 Hours) DC Motors Characteristics, Speed and Torque Control, Regenerative Braking.
AC Motors Characteristics, Speed and Torque Control. PM- BLDC Motors Characteristics, Speed and Torque Control.Reluctance Motors Characteristics, Speed and Torque Control, Regenerative Braking.

UNIT V: ENERGY STORAGES & GENERATORS (08 Hours)

Electrochemical Batteries: Types of Batteries, Lead-Acid Batteries, Nickel Based Batteries, Lithium Based Batteries, Electro Chemical Reactions, Thermodynamic Voltage, Specific Energy, Specific Power, Energy Efficiency, Ultra Capacitors, DC Generators, AC Generators, Voltage and Frequency Regulations

References Books:

1) Mehrdad Ehsani, Yimin Gao, Sebatien Gay and Ali Emadi, "Modern Electric, Hybrid Electric and Fuel cell vehicles: Fundamentals, Theory and Design", CRC Press, 2004.
2) James Larminie and John Loury, "Electric Vehicle Technology – Explained", John Wiley & Sons Ltd, 2003.
3) Sandeep Dhameja, "Electric Vehicle Battery Systems", Butterworth – Heinemann, 2002.
4) Ronald K Jurgen, "Electric and Hybrid – Electric Vehicles", SAE, 2002.
5) Ron Hodkinson and John Fenton, "Light Weight Electric/Hybrid Vehicle Design", Butterworth –Heinemann, 2001.
6) Iqbal Husain, "Electric and Hybrid Vehicles- Design Fundamentals" CRC Press, 2011.

24AF2293PE301(C) CONTROL SYSTEM DESIGN AND ESTIMATION Credits03

Prerequisites:

Undergraduate-level Control Systems, Signals and Systems, Linear Algebra and Differential Equations

Course Objectives:-

1. Develop an in-depth understanding of control system design in state-space and frequency domains.
2. Introduce estimation techniques for dynamic systems using observers and filters.
3. Equip students with tools to analyze system stability, performance, and robustness.
4. Provide hands-on experience with MATLAB/Simulink and real-time hardware for control and estimation tasks.
5. Enable the application of design and estimation concepts to electrical systems such as converters, machines, and grid systems.

Course Outcomes:

Upon successful completion of this course the student will be able to:

CO1	Design feedback controllers using state-space and frequency-domain techniques.
CO2	Model and simulate dynamic systems and evaluate control performance.
CO3	Design state observers and Kalman filters for system estimation.
CO4	Apply control and estimation techniques to real-world electrical engineering problems.
CO5	Utilize computational tools for control design and estimation implementation.

Course contents:

UNIT.1. Review of Linear Systems and State-Space Models (08 Hours)

Linear time-invariant (LTI) systems, Controllability and observability, Canonical forms and transformations

UNIT.II. State Feedback and Pole Placement (08 Hours)

Pole assignment using state feedback, Ackermann's formula, Effect of state feedback on system dynamics, Full and partial state feedback

UNIT.III. Observer Design and Estimation Basics (08 Hours)

Need for observers, Luenberger observer design, Reduced-order observers, Duality between control and estimation

UNIT.IV. Optimal Control and LQR Design (08 Hours)

Performance indices**,**Linear Quadratic Regulator (LQR)**,**Trade-off between performance and control effort**,**Infinite vs. finite time horizon

Estimation Using Kalman Filters (08 Hours)

Stochastic systems and noise models**,** Discrete Kalman filter design**,** Extended Kalman filter for nonlinear systems**,**Application in sensor fusion and fault detection

UNIT.V. Frequency Domain Design Techniques (08 Hours)

Bode and Nyquist plots, Loop shaping and gain/phase margin, Lead-lag compensation and PID tuning, Robustness and sensitivity functions

UNIT.VI. **Modern Control Applications in Electrical Engineering (10 Hours)**

Control of DC-DC converters**,** Motor control using observers and LQR**,**Estimation in smart grids and power systems**,**Real-time implementation using DSPs/FPGAs

Simulation exercises in MATLAB/Simulink**,** Observer and controller design for electrical systems

References Books:

1. **Ogata, Katsuhiko**, *Modern Control Engineering*, Pearson.
2. **Gopal, M.**, *Modern Control System Theory*, New Age International.
3. **Dorf & Bishop**, *Modern Control Systems*, Pearson.
4. **Goodwin, Graebe, Salgado**, *Control System Design*, Prentice Hall.
5. **Frank L. Lewis**, *Optimal Control*, Wiley.
6. **Simon Haykin**, *Kalman Filtering and Neural Networks*, Wiley.
7. **Brian D.O. Anderson & John B. Moore**, *Optimal Filtering*, Dover Publications.

8. IEEE Transactions on Control Systems Technology, Industrial Electronics, and Smart Grids.
9. MATLAB Control System Toolbox and Simulink Demos.

24AF2293OE302	Open Elective II	Credits03

Course Code	NPTEL Course	Credits	Name of Instructor	Host Institute	Link
24AF2293OE302**A**	Student Psychology	3	Dr. S.Renukadevi	National Institute of Technical Teachers Training and Research, Chennai	https://onlinecourses.swayam2.ac.in/ntr19_ed23/preview
24AF2293OE302**B**	Business To Business Marketing(B2B)	3	Prof. J. K. Nayak	IIT Roorkee	Business To Business Marketing (B2B) - Course(nptel.ac.in)
24AF2293OE302**C**	Organizational Behaviour	3	Prof. M. P.Ganesh	IIT Hyderabad	Organizational Behaviour - Course(nptel.ac.in)
24AF2293OE302**D**	Principles Of Economics	3	Prof. SabujKumar Mandal	IIT Madras	Principles Of Economics - Course(nptel.ac.in)

24AF2293MD303	Multidisciplinary Minor	Credits03

Course Code	NPTEL Course	Credits	Name of Instructor	Host Institute	Link
24AF2293MD30A	Design Of Mechatronic Systems	3	Prof. Prasanna Gandhi	IIT Bombay	Design Of MechatronicSystems - Course(nptel.ac.in)
24AF2293MD30B	Ethical Hacking	3	Prof. Indranil Sengupta	IIT Kharagpur	Ethical Hacking - Course(nptel.ac.in)
24AF2293MD30C	Sustainable Power Generation Systems	3	Dr.Pankaj Kalita	IIT Guwahati	Sustainable PowerGeneration Systems - Course(nptel.ac.in)

24AF2293MD30D	Components And Applications of Internet of Things	3	Dr. Sanjoy Kumar Parida	Indian Institute of Technology Patna	https://onlinecourses.swayam2.ac.in/arp20_ap03/preview

23U2901ES304 Environmental Studies Credits04

Course Objectives:

1. Provide students with a comprehensive understanding of key environmental concepts, principles, and challenges, enabling them to grasp the interconnected ness of ecological systems and human activities.
2. Develop students' analytical skills to assess environmental issues from scientific, economic, social, and ethical perspectives, fostering the ability to evaluate potential solutions and trade-offs.
3. Cultivate a strong awareness of sustainable practices, enabling students to identify and promote environmentally responsible behaviors in personal, professional, and community contexts.
4. Broaden students' horizons by exploring global environmental issues and their impact on diverse cultures and regions, promoting a sense of stewardship and a commitment to addressing international environmental challenges.

Course Outcomes:

1. To provide knowledge about multidisciplinary nature of environment, various sources of natural energy, ecosystem, social issues, and the environment, etc.
2. Students will be evaluated upon achievement in terms of academic excellence.
3. Students will also be able to understand about the various environmental issues and problems associated with the human population and the environment.

UNIT I [7Hr]

Concept of Environment, Land: A Natural Resource, Natural Resource: Forest, The Story of Water, Treasure of Earth Global Food Position: Challenges and Solutions, Renewable Energy Resources: Energy and Environment, Energy & Environment, Part-1, Dams: Boon or Curse, Fresh Water Ecology, Reservoir Ecosystem, Part-1

UNIT II [7Hr]

Reservoir Ecosystem, Part-2, The Concept of Ecosystem, Energy Flow in Ecosystem, Eco

Friendly Agriculture, Desert Ecosystem, Forest Ecosystem, Ecological Succession, Food Webs & Ecological Pyramids, Grass Land Ecosystem Bio-Geographical Classification of India, Natural Dye, Biodiversity: An Introduction, Biodiversity, and Its Conservation, Biodiversity at Global National and Local- Level, Threats to Biodiversity, Value of Biodiversity, Endangered Common Plant and Animal Species

UNIT III **[7Hr]**

India As-A Mega diversity Nation, Types of Noise Pollution, Air Pollution, Soil Pollution ,Effects of Noise Pollution, Role of An Individual in Prevention of Pollution, Land Slides Cyclone, Flood, Earth Quake sand Disaster Management, The Changing Nature of Earth

UNIT IV **[6Hr]**

Basics Of Municipal Solid Waste, Management of Municipal Solid Waste, Agony of Seas, The Price of Panacea-Biomedical Waste, Effects and Controls of Water Pollution Nuclear Hazards, Industries & Waste, Dealing with Industrial Waste, Environmental Rights, Environmental Threats, Public Environmental Awareness, Ethics of Environmental Education, Environmental Values

UNIT V **[6Hr]**

Indian Legislative Steps to Protect Our, Environment, Water Management Practices, Sustainable Development, Urban Problems Related to Energy, Resettlement and Rehabilitation Environment And Climate Change, Sex Ratio, Population Explosion, Impact of Human Population on Environment, Infectious Diseases and Waterborne Diseases

UNIT VI **[6Hr]**

HIV/Aids, Cancer & The Environment, Environment and Human Health, Chemicals in Food, Typha: A Bio-Remedial Plant, Castor Bean, Pinus Malaria, Machla: A Serene Village, The Secret of Taste – Chilli, Common Avenue – Trees, Common Village Trees, Flower - The Beautiful Gift of Nature, Silk Cotton Tree: Kapok, Cotton Yarn

Textbooks/References:

1. Bharucha, Erach(2005):"Text Book of Environmental Studies for Undergraduate Courses", Universities Press (India) pvt ltd, Hyderabad, India.
2. IGNOU–1991–AHE-1/5–Human Environment Management of Environment-Indira Gandhi open university, New Delhi
3. IGNOU1995–FST-1/4Foundation course in Science and Technology "Environment and Resource"-Indira Gandhi open university, New Delhi
4. Kothari Dr. Milind –2005–Environmental Education –Universal Publication, Agra.

23U2901PC305	Project-I	Credits10

In-house Project Part-I

The phase–I of in house project for the students those are not doing Internship in the Industry, such students can do project work in the dept. It is expected that students should finalize objective of the work, literature survey, tools and techniques, design and simulation of the project. Assessment will be based on the work carried out by the student, report submitted and evaluation will done for this.

SEMESTERIV

23U2901PC401	Project II	Credits 20

In House Project Part-II

In phase-II of In-house project, work should consist of detailed report for chosen topic and output of work proposed in IIIrd semester, in addition to the contents specified in semester IIIrd. Assessment will be done based on the work carried out by the student.