DR. BABASAHEB AMBEDKAR TECHNOLOGICAL UNIVERSITY, LONERE -402103

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Structure and syllabus of M. Tech. (Electrical Power Systems)

National Education Policy (NEP) 2020

With effect from the Academic Year
2023-2024

M. Tech Electrical Power System

Program Educational Objectives:

1. To prepare graduates 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 Power System

M. Tech Course Structure and syllabus for Electrical (Electrical Power System) AY 2023-24											
	Course Code	**Course Title**	**Teaching Scheme**			**Marking Scheme**			**Total Marks**	**Cr**	**Category**
			L	**T**	**P**	**CA**	**MSE**	**ESE**			
SEM- I	23U2901PC101	Power System Modeling	3	1	-	20	20	60	100	4	PCC
	23U2901PC102	Advanced Power Electronics	3	1	-	20	20	60	100	4	PCC
	23U2901PE103	Program Elective-I	3	1	-	20	20	60	100	4	PE
	23U2901PE104	Program Elective-II	3	1	-	20	20	60	100	4	PE
	23U2612OE105	Research Methodology	4	-	-	20	20	60	100	4	ELC
	23U2901PCL106	PG Lab-I	-	-	2	25		25	50	1	PCC
	23U2901PCL107	PG Lab-II	-	-	2	25		25	50	1	PCC
	23U2901AU108	YOGA for Stress Management	2	-	-	50			50	-	Audit Course
		Total	**18**	**4**	**4**					**22**	
	Course Code	**Course Title**	**Teaching Scheme**			**Marking Scheme**			**Total Marks**	**Cr**	**Category**
			L	**T**	**P**	**CA**	**MSE**	**ESE**			
SEM- II	23U2901PC201	Power System Dynamics and Control	3	1	-	20	20	60	100	4	PCC
	23U2901PC202	Advance Power System Protection	3	1	-	20	20	60	100	4	PCC
	23U2901PE203	Program Elective-III	3	-	-	20	20	60	100	3	PE
	23U2901OE204	Open Elective I	3	-	-	20	20	60	100	3	OE
	23U2901OE205	Intellectual Property & Rights**	3	-	-	20	20	60	100	3	OE
	23U2901PCL206	PG Lab-III	-	-	2	25		25	50	1	PCC
	23U2901PCL207	PG Lab-IV	-	-	2	25		25	50	1	PCC
	23U2901IK102	IKS Bucket#	2	-	-	20	20	60	100	2	AEC/VEC/IKS
	23U2901AU102	Disaster Management	2	-	-	50			50	-	Audit Course
		Total	**19**	**2**	**4**					**21**	

	Course Code	Course Title	Teaching Scheme			MarkingScheme			Total Marks	Cr	Category
			L	T	P	CA	MSE	ESE			
SEM- III	23U2901PE301	Program Elective IV	3	-	-	20	20	60	100	3	PE
	23U2901OE302	Open Elective II	3	-	-	20	20	60	100	3	OE
	23U2901MD303	Multidisciplinary Minor	3	-	-	20	20	60	100	3	MDM**
	23U2901ES304	Environmental Studies	4	-	-	20	20	60	100	4	HSSM **
	23U2901PC305	Project I***	-	-	-	50		50	100	10	ELC
		Total	**13**							**23**	
SEM- IV	23U2901PC401	Project II	-	-	-	50		50	100	20	ELC
		Total								**20**	

Credit Distribution

SEM I	SEM II	SEM III	SEM IV	Total
22	**21**	**23**	**20**	**86**

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 22 credits 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
23U2901PE103**A**	High Voltage Power Transmission.	4
23U2901PE103**B**	Advanced Topics in Power System.	4
23U2901PE103**C**	Electrical Transients in Power System	4

Program Elective II Courses

Sr. No.	Course Title	Credits
23U2901PE104**A**	Power System Planning and Reliability.	4
23U2901PE104**B**	Power Quality Assessment and Mitigation.	4

23U2901PE104**C**	Advance Control System.	4

Program Elective III Courses

Course Code	Course Title	Credits
23U2901PE203A	Power Sector Economics Restructuring & Regulation	3
23U2901PE203B	Smart Grid Design and Analysis	3
23U2901PE203C	Distributed generation and micro grid.	3

Program Elective IV Courses

Course Code	Course Title	Credits
23U2901PE301**A**	Application of Power Electronics to Power System.	3
23U2901PE301**B**	Modelling and Simulation of Power Electronics System.	3
23U2901PE301**C**	A I Techniques in Power System	3

Open Elective I (Bucket)

Couse Code	NPTEL Course	Credits	Name of Instructor	Host Institute	Link
23U2901OE204A	New Labour Codes of India	3	Prof. KD Raju	IIT Kharagpur	https://onlinecourses.nptel.ac.in/noc23_lw05/preview
23U2901OE204B	Urban Utilities Planning: Water Supply, Sanitation and Drainage	3	Prof. Debapratim Pandit	IIT Kharagpur	https://onlinecourses.nptel.ac.in/noc23_ar08/preview
23U2901OE204C	Environment and Development	3	Prof. Ngamjahao Kipgen	IIT Guwahati	https://onlinecourses.nptel.ac.in/noc21_hs83/preview
23U2901OE204D	Entrepreneurship	3	Prof. C Bhaktavatsala Rao	IIT Madras	https://onlinecourses.nptel.ac.in/noc20_mg35/preview

Open Elective II (Bucket)

Couse Code	NPTEL Course	Credits	Name of Instructor	Host Institute	Link
23U2901OE302**A**	Student Psychology	3	Dr. S. Renukadevi	National Institute of Technical Teachers Training and Research, Chennai	https://onlinecourses.swayam2.ac.in/ntr19_ed23/preview
23U2901OE302**B**	Business To Business Marketing (B2B)	3	Prof. J. K. Nayak	IIT Roorkee	Business To Business Marketing (B2B) - Course (nptel.ac.in)
23U2901OE302**C**	Organizational Behaviour	3	Prof. M. P. Ganesh	IIT Hyderabad	Organizational Behaviour - Course (nptel.ac.in)
23U2901OE302**D**	Principles Of Economics	3	Prof. Sabuj Kumar Mandal	IIT Madras	Principles Of Economics - Course (nptel.ac.in)

Multidisciplinary Minor bucket

Couse Code	NPTEL Course	Credits	Name of Instructor	Host Institute	Link
23U2901MD303A	Design Of Mechatronic Systems	3	Prof. Prasanna Gandhi	IIT Bombay	Design Of MechatronicSystems - Course (nptel.ac.in)
23U2901MD303B	Ethical Hacking	3	Prof. Indranil Sengupta	IIT Kharagpur	Ethical Hacking - Course (nptel.ac.in)
23U2901MD303C	Sustainable Power Generation Systems	3	Dr. Pankaj Kalita	IIT Guwahati	Sustainable Power Generation Systems - Course (nptel.ac.in)
23U2901MD303D	Components And Applications of Internet of Things	3	Dr. Sanjoy KumarParida	Indian Institute of TechnologyPatna	https://onlinecourses.swayam2.ac.in/arp20_ap03/preview

IKS (Bucket)

Couse Code	NPTEL Course	Credits	Name of Instructor	Host Institute	Link
23U2901IK102A	Indian Knowledge System (IKS): Concepts and Applications in Engineering	4	Prof. B. Mahadevan, Dr. Vinayak Rajat Bhat,Dr. R Venkata Raghavan	Prof. B. Mahadevan,Dr. VinayakRajat Bhat, Dr. R Venkata Raghavan	https://onlinecourses.swayam2.ac.in/imb23_mg53/preview
23U2901IK102B	Indian Knowledge System(IK): Humanities and Social Sciences	4	Prof. B. Mahadevan, Dr. Vinayak Rajat Bhat,Dr. R Venkata Raghavan	Indian Institute of Management Bangalore (IIMB), Chanakya University, Bangalore	https://onlinecourses.swayam2.ac.in/imb23_mg55/preview
23U2901IK102C	Ancient Indian Management	2	Dr. Alka Jain	Taxila Business School	https://onlinecourses.swayam2.ac.in/aic22_ge19/preview

Syllabus for Electrical Power System (M. Tech Firstyear)

SEMESTER I

23U2901PC101	POWER SYSTEM MODELING	04 Credits

Course Objective:

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

Course Outcomes:

CO1	Develop power system components modeling and analyze their performance
CO2	Develop modeling 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 modeling and analyze their performance.
CO6	Understand and transmission line, load and reactive power compensator modeling.

Course Content

UNIT-1: Modeling of Power System Components: [8 Hours]

The need for modeling of power system, different areas of power system analysis. Models of non-electrical components like boiler, steam & hydro-turbine & governor system. Transformer modeling such as auto-transformer, tap-changing & phase shifting transformer.

UNIT-2: Synchronous machine modeling [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 modeling [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 modeling [7 Hours]

Excitation control systems using dc generator exciter, alternator-rectifier, alternator SCR, andvoltage regulators such as electro-mechanical and solid state. Modeling of excitation systems.

UNIT-6-Transmission line, SVC and load modeling: [6 Hours]

Transmission line modeling, Modeling of static V AR compensators, load modeling.

Reference books:

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

23U2901PC102	ADVANCED POWER ELECTRONICS	Credits 04

Pre-Requisites: Power Electronics, Circuit theory.
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 design and simulate different power converters using MATLAB Simulink.

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	Analyse operation of various power converters
CO3	Understand advance power conversion techniques
CO4	Able to design multilevel converters
CO5	Able to design different power converters using MATLAB Simulink.

Course content:

UNIT-I Overview of Switching Power Devices: **(7 Hrs)**
Solid State Power Semi-Conducting Devices: Review of the thyristors, TRIAC, GTO, BJT, MOSFET and other modem power devices (IGBT, SIT), characteristics ratings, commutation methods, protection and requirement of firing circuits.
UNIT-II Phase Controlled Rectifiers: **(7 Hrs.)**
Principle of phase-controlled converter operation- single phase full converter and semi converters- dual 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: **(7 Hrs.)**
Study of Class – A- B- C- and D choppers- non-isolated DC-DC converters: buck-boost- buck boost 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: **(8 Hrs.)**

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 Introduction to Multilevel Converters **(6 Hrs.)**

Basic Characteristics, Multilevel DC/DC Converters, Multilevel Inverters, Control of Multilevel Inverters.

UNIT – VI Simulation of Power Electronics Converters **(7 Hrs.)**

Introduction, importance of simulation, simulation tools, some examples such as analysis of a full bridge rectifier, analysis of a buck converter, dynamic stability analysis of a buck converter, analysis of a half bridge-bridge SMPS topology.

Reference Books:

1. Power Electronics-circuits, Devices & Applications, M.H. Rashid: 4th Edition, PHI, 2017.
2. Power Electronics, Dr. P. S. Bimbhra: 7th revised edition, Khanna Publication, 2022
3. Power Electronics: Converters, Applications, Ned Mohan, T.M. Undeland, William P.Robbins: 3rd ed., John Wiley & Sons, 2009.
4. Power Electronics, M S Jamil Asghar, PHI publication.
5. Power Electronics Converters and regulators, Branko L. Dokic, Branko Blanusa, 3rd Edition, Springer

23U2901PE103A	HIGH VOLTAGE POWER TRANSMISSION	Credits 04

Pre-Requisites: Electromagnetic theory, Power electronics, Power system operation andprotection.

Course Objective

- To understand basic philosophy of EHV AC transmission.
- To understand the concept of voltage gradient and effect of electrostatic field.
- To understand the electromagnetic interference, AN, RI.
- To understand basic concepts of design of EHV AC transmission system.

Course Outcome

Upon successful completion of this coursestudents will be able to:

CO1	Understand the engineering aspectsof EHV AC transmission system.
CO2	Understand and analyze various transients in transmission line
CO3	Design transient protection for power system
CO4	Understandmaintenance procedure, tools and safety precautions.
CO5	Understandthe voltage control principles.

CO6	Understand different configuration, design procedure, protection requirements of HVDC line.

Course contents:

UNIT-I: Engineering Aspects of EHV AC Transmission System. [7 Hours]

Principles, configuration, special features of high voltage AC lines, power transfer ability, reactive power compensation, audible noise, corona bundle conductors, electric field, right of way, clearances in a tower, phase to phase, phase to ground, phase to tower, factors to be considered, location of ground wire, angle of protection, clearances, tower configuration.Principles of radio interference, origin of radio interference, method of propagation, factors to be considered in line design.

UNIT-II: Power System Transients [7 Hours]

Introduction, circuit closing transients, sudden symmetrical short circuit of alternator, recovery transients due to removal of short circuit, traveling waves on transmission lines, wave equation, surge impedance and wave velocity, specifications of traveling waves, reflection and refraction of waves, typical cases of line terminations , equivalent circuit for traveling wave studies, forked lines, reactive termination, successive reflections, Bewley lattice diagram, attenuation and distortion, arcing grounds, capacitance switching, current chopping, lightning phenomenon, over voltages due to lightning, line design based on direct strokes, protection of systems against surges, statistical aspects of insulation coordination.

UNIT-III: Other Issues [7 Hours]

Biological effects of electric field, safe values of electric field, requirements of transmission line, live line maintenance, basic principle, special tools and procedure, methods of voltage control, tap changing, shunt compensation, shunt rectors and shunt capacitors.

UNIT-IV: General Background [7 Hours]

EHV AC versus HVDC Transmission, power flow through HVDC link, equation for HVDC power flow, effect of delay angle and angle of advance, bridge connections, waveform of six pulse and twelve pulse bridge converter, commutation, phase control, angle of extinction, control of DC voltage, connections of three phase six pulse and twelve pulse converter bridges, voltage and current waveforms.

UNIT-V: HVDC Transmission [7 Hours]

Bipolar HVDC terminal, converter transformer connections, switching arrangements in DC yard for earth return to metallic return, HVDC switching system, switching arrangements in a bipolar HVDC terminal, sequence of switching operations, HVDC circuit breakers, DC current interruption, commutation principle, probable types and applications of HVDC circuit breakers, multi-terminal HVDC systems, parallel tapping, reversal of power, configurations and types of multi-terminal HVDC systems, commercial multi terminal systems.

UNIT-VI: Protection of HVDC **[7 Hours]**

Faults and abnormal condition in bipolar, two terminal HVDC system, pole-wise segregation, protective zones, clearing of DC line faults and reenergizing, protection of converters, transformer, converter valves, DC yards, integration of protection 'and controls, hierarchical levels of control, block diagram, schematic diagram, current control, power control, DC voltagecontrol, commutation channel, master control, station control, lead station, trail station, pole control, equidistant firing control, synchronous HVDC link, asynchronous HVDC Link.

References:

1. An Introduction to High Voltage Engineering by Subir Ray, Prentice Hall of India Private Limited, New Delhi - 110 001.
2. Direct Current Transmission Vol-I, Kimbark E. W , Wiley Interscience
3. HVDC Transmission- Adamson C. Hingorani N. G.
4. EHV AC Transmission Rakosh Das Begamudre, New Age Publishers
5. HVAC and HVDC Transmission, Engineering and practice: S. Rao, Khanna Publisher, Delhi.
6. Electric Power Systems: B.M. Weddy and B.J. Cory, John Wiely and Sons, Fourth edition
7. Power System Analysis and Design : J. Duncan Glover, Mulukutla S. Sarma,ThomsonBrooks/cole/ Third Edition (2003)
8. Power System Analysis and Design, B.R. Gupta, S. Chand and Company (2004) Foundation and Applications, Cambridge Press, 2002.

23U2901PE103B	ADVANCE TOPICS IN POWER SYSTEM	Credits 04

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 WileyAnd 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 andControl.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 AcademicPress (U.K.), 1999.
9. Power System Analysis andDesign.B.R. Gupta, III Edition, A.H. Wheeler & Co. Ltd., NewDelhi, 1998.
10. Reactive Power Control in Electric Power Systems.T.J.E. Miller John Wiley and Sons,New York, 1982.

23U2901PE103C 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.

Course contents:

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

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 andsymmetrical 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 ofsingle-core 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 Greenwood Wiley & Sons Inc. New York, 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 PublishingCompany Ltd., New Delhi, 2004.

4. EMTP Theory Book, Hermann W. Dommel, second Edition, Microtran Power System Analysis

5. corporation, Vancouver, British Columbia, Canada, May 1992, Last Update: April 1999. EMTP Literature from www.microtran.com.

23U2901PE104A	POWER SYSTEM PLANNING AND RELIABILITY	Credits 04

Pre-Requisites: Power system operation and control

Couse objectives:-

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

- To familiarize the students with various aspects of probability theory
- To acquaint the students with reliability and its concepts
- To introduce the students to methods of estimating the system reliability of simple andcomplex systems
- To understand the various aspects of Maintainability, Availability and FMEA procedure

Course Outcomes:

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

CO1	Understand load forecasting and planning techniques in power system
CO2	Understand concepts of reliability to design secure and reliable networks.
CO3	Carry out planning and reliability for generation, transmission, and distribution system

Course contents:

UNIT-I Load Forecasting **[7 Hours]**

Introduction, Factors affecting Load Forecasting, Load Growth Characteristics, Classification of Load and Its Characteristics, Load Forecasting Methods (i) Extrapolation (ii) Co-Relation Techniques, Energy Forecasting, Peak Load Forecasting, Reactive Load Forecasting, Non- Weather Forecasting, Weather Forecasting, Annual Forecasting, Monthly Forecasting, Total Forecasting.

UNIT-II System Planning **[7 Hours]**

Introduction, Objectives & Factors affecting to System Planning , Short Term Planning, Medium Term Planning, Long Term Planning, Reactive Power Planning.

UNIT-III Reliability **[7 Hours]**

Reliability, Failure, Concepts of Probability, Evaluation Techniques (i) Markov Process (ii) Recursive Technique, Stochastic Prediction of Frequency and Duration of Long & Short Interruption, Adequacy of Reliability, Reliability Cost.

UNIT-IV Generation Planning and Reliability **[7 Hours]**

Objectives & Factors affecting Generation Planning, Generation Sources, Generation System Model, Loss of Load (Calculation and Approaches), Outage Rate, Capacity Expansion, Scheduled Outage, Loss of Energy, Evaluation Methods. Interconnected System, Factors Affecting Interconnection under Emergency Assistance.

UNIT-V Transmission Planning and Reliability **[7 Hours]**

Introduction, Objectives of Transmission Planning, Network Reconfiguration, System and Load Point Indices, Data required for Composite System Reliability.

UNIT-VI Distribution Planning and Reliability **[7 Hours]**

Radial Networks - Introduction, Network Reconfiguration, Evaluation

Techniques, Interruption Indices, Effects of Lateral Distribution Protection, Effects of Disconnects, Effects of Protection Failure, Effects of Transferring Loads, Distribution Reliability Indices.

Parallel & Meshed Networks - Introduction, Basic Evaluation Techniques, Bus Bar Failure, Scheduled Maintenance, Temporary and Transient Failure, Weather Effects, Breaker Failure.

References:

1. Modern Power System Planning - X. Wang & J.R. McDonald, McGraw Hill BookCompany
2. Power System Planning - R.N. Sullivan, Tata McGraw Hill Publishing Company Ltd.
3. Electrical Power Distribution Engineering - T. Gonen, McGraw Hill Book Company
4. Reliability Evaluation of Power System - Roy Billinton & Ronald N. Allan,Springer Publication
5. Generation of Electrical Energy - B.R. Gupta, S. Chand Publications
6. Electrical Power Distribution A.S. Pabla Tata McGraw Hill Publishing Company Ltd.7.Electricity Economics & Planning - T.W.Berrie, Peter Peregrinus Ltd., London

23U2901PE104B POWER QUALITY ASSESSMENT AND MITIGATION Credits 04

Pre-Requisites: Electromagnetic theory (desirable)

Course Objectives:-

- To know various power quality issues, it causes and effects
- To understand effects of harmonics due to non-linear load
- To learn mitigation methods for harmonics

Course Outcomes:

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

CO1	Understand the different power quality issues and standards
CO2	Understand the power monitoring importance and monitoring procedure to access the power quality
CO3	Apply the mitigation techniques to reduce the adverse effects of power quality on system and equipment

UNIT-I Introduction **[7 Hours]**

Importance of power quality, terms and definitions of power quality as per IEEE std. 1159 suchas transients, short and long duration voltage variations, interruptions, short and long voltagefluctuations, imbalance, flickers and transients. Symptoms of poor power quality. Definitions and terminology of grounding. Purpose of groundings. Good grounding practices and problems due to poor grounding.

UNIT-II Flickers & transient voltage **[7 Hours]**

RMS voltage variations in power system and voltage regulation per unit system, complex power. Principles of voltage regulation. Basic power flow and voltage drop. Various devices used for voltage regulation and impact of reactive power management. Various causes of voltage flicker and their effects. Short term and long term flickers. Various means to reduce flickers. Transient over voltages, sources, impulsive transients, switching transients, Effect of surge impedance and line termination, control of transient voltages

UNIT-III Voltage sag and interruptions **[7 Hours]**

Definitions of voltage sag and interruptions. Voltage sags versus interruptions. Economic impact of voltage sag. Major causes and consequences of voltage sags. Voltage sag characteristics. Voltage sag assessment. Influence of fault location and fault level on voltage sag. Areas of vulnerability. Assessment of equipment sensitivity to voltage sags. Voltage sag requirements for computer equipment, CBEMA, ITIC, SEMI F 42 curves. Representation of theresults of voltage sags analysis. Voltage sag indices. Mitigation measures for voltage sags, such as UPS, DVR, SMEs, CVT etc., utility solutions and end user solutions

UNIT-IV Waveform Distortion **[7 Hours]**

Definition of harmonics, interharmonics, subharmonics. Causes and effect of harmonics. Voltage versus current distortion. Overview of Fourier analysis. Harmonic indices. A.C. quantities under non-sinusoidal conditions. Triplen harmonics, characteristics and non- characteristics harmonics. Harmonics series and parallel resonances. Consequences of harmonicresonance. K-rated transformer. Principles for controlling harmonics. Reducing harmonic currents in loads. Harmonic study procedure. Computer tools for harmonic analysis. Locating sources of harmonics. Harmonic filtering, passive and active filters. Modifying the system frequency response. IEEE Harmonic standard 519-1992

UNIT-V Power Quality Monitoring **[7 Hours]**

Need of power quality monitoring and approaches followed in power quality monitoring. Power quality monitoring objectives and requirements. Initial site survey. Power quality Instrumentation. Selection of power quality monitors, selection of monitoring location andperiod. System wide and discrete power quality monitoring. Setting thresholds on monitors, d data collection and analysis. Selection of transducers. Harmonic monitoring, transientmonitoring, event recording and flicker monitoring.

UNIT-VI Power Quality Assessment and Mitigation **[7 Hours]**

Power Quality assessment, Power quality indices and standards for assessment disturbances, waveform distortion, voltage and current unbalances. Power assessment under waveform distortion conditions. Power quality state estimation, State variable model, observity analysis, capabilities of harmonic state estimation. Test systems. Mitigation techniques at different environments

References:

1. Understanding power quality problems, voltage sag and interruptions
- M. H. J. BollenIEEE press, 2000, series on power engineering.
2. Electrical power system quality - Pogei G. Dugan, Mark F. McGranghan, Surya santoso, H.Wayne Beaty, second edition, McGraw Hill Pub.
3. Power system quality assessment - J. Arrillaga, M.R. Watson, S. Ghan, John Wiley and sons.

23U2901PE104C	ADVANCED CONTROL SYSTEM	Credits 04

Course Objectives:

1) To make students understand the concept of nonlinear control, Adaptive Control andSliding mode control
2) To study the behavior of nonlinear systems using various techniques.

Course outcomes:

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

CO1	Understand various control system design techniques.
CO2	Evaluate performance analysis of non linear system using various techniques.

Course Contents:

UNIT-I: **[8hrs]**

Control system design by root locus method-lead, lag and lead lag compensation. PI, PD and PIDcontrollers design procedures and examples. Control system design by frequency response approach- lead, lag and lead lag compensation. PI,PD and PID controllers design procedures and examples.

UNIT- II: EIGEN VALUE AND EIGENVECTOR SENSITIVITIES IN LINEAR SYSTEM THEORY **[7hrs]**

Continuous time systems: Introduction, first-order Eigen value sensitivities, first order eigenvector sensitivities, second-order Eigen value sensitivities, first order eigenvector sensitivities, second order Eigenvector sensitivities.

UNIT- III: MODE-CONTROLLABILITY MATRIX: **[8hrs]**

Distinct Eigen-values, confluent Eigen-values associated with single Jordan block, confluent Eigen-values associated with number of distinct Jordan blocks, confluent Eigen-values associated with a number of non-distinct Jordan block. Mode – Controllability structure of multivariable linear systems: Introduction, Distinct Eigen-values, confluent Eigen-values associated with single Jordan block, confluent Eigen-values associated with a number of non- distinct Jordan blocs.

UNIT- IV: OBSERVABILITY MATRICES: **[9hrs]**

Distinct Eigen-values, confluent Eigen-values, mode observability structure of multivariable linear systems: Introduction, Distinct Eigen-values, confluent

Eigenvalues. Nonlinear systems: Common physical nonlinearities: the phase plane method – basic concept, singular points,construction of phase trajectories – Isocline and delta methods, Describing function – basic concept – derivation of describing functions – stability analysis by describing function method.

UNIT- V: LYAPUNOV STABILITY ANALYSIS: . **[10 hrs]**

Second method of Lyapunov, stability in the sense of Lyapunov, construction of Lyapunov functions – Krasovskii's and variable gradient methods, Lyapunov stability analysis of linear time varying systems

TEXT BOOKS:

1. Advanced Control Systems B. N. Sarkar, PHI Learning Private Limited.
2. Advanced Control Theory, Somanath Majhi, Cengage Learning.
3. Control System Engineering – I J Nagarath, M. Gopal – New Age International – 3rdedition.
4. Control Systems – N K Sinha – New Age International – 3rd edition.

23U2612OE105	Research Methodology	Credits 04

Course Objectives:

1. To develop a research orientation among the scholars and to acquaint them withfundamentals 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 andtechniques
4. Learner will have overview knowledge of modelling and simulation of research work
5. Learner will be able to collect the statistical data with different methods related toresearch work
6. Learner will be able to write their own research work with ethics and non-plagiarizedway.

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 ofWorking 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 WritingResearch 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

List of experiments:

Experiment 1: To study of transformer modelling

Experiment 2: To study of Excitation modelling for synchronous machine

Experiment 3: to study mathematical analysis of synchronous machine modelling

Experiment 4: to study deterministic contingency analysis of transmission system

Experiment 5: To study the mathematical analysis of a discrete state, continuous transition maker process

Experiment 6: To study the biological effects of HVDCCC and EHV

AC on human being, plants, and animals.

Experiment 7: to study Towers for transmission line and substation

Structure.

Experiment 8: To study the thermal, electrical, and mechanical loading Effects on EHV system.

23U2901PCL107	PG-LAB-II	Credits 04

List of experiments:

Experiment 1: To study single phase full wave-controlled rectifier with Resistive Inductive (RL) load.

Experiment 2: To study Single-phase AC voltage controller with Resistive(R) & Resistive Inductive (RL) loads

Experiment 3: To study Single Phase Diode Bridge Rectifier with R load and capacitance filter

Experiment 4: To study Single Phase Series Inverter with Resistive(R) & Resistive Inductive (RL) loads

Experiment 5: Design and Simulation of single phase and three phase semi-converter**.**

Experiment 6: Design and Simulation of buck-boost converter.

Experiment 7: Design and simulation of 4 level DC-DC converter

Experiment 8: Design and simulation of Cascaded H-bridge p-level inverter

23U2901AU108	Yoga for Stress Management	Audit Course

Course Objectives:

1. Understand the physiological and psychological aspects of stress and its impact onoverall 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 lifestylehabits 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 andphysical well-being.
2. Master a variety of yoga techniques, including postures, breathing, and meditation, toeffectively 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 balanceand 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 PerspectiveStress Hazards and Yoga

UNIT II
Meeting the challenges of Stress - 1Meeting the challenges of Stress - 2
Introduction to Stress Physiology
Stress, Appetite and Dietary management- 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 ofresearch evidence
Concept of stress and its management - perspectives from Patanjali Yoga Sutra - Part 1Concept of stress and its management - perspectives from Patanjali Yoga Sutra - Part 2 Concept of stress and its management - perspectives from Patanjali Yoga Sutra - Part 3

UNIT IV
Concept of stress and its management - perspectives from Bhagavad Gita - Part 1Concept of stress and its management - perspectives from Bhagavad Gita - Part 2 Concept of stress and its management - perspectives from Bhagavad Gita - Part 3

UNIT V
Bio-Psycho-Socio-Spiritual model of stress managementYoga practices for Stress Management
Breathing practices – 1
Hands in and out breathing, Hands stretch breathing, Ankle stretch breathingBreathing practices – 2
Dog Breathing, Rabbit breathing, Tiger breathing, Sashankasana breathingBreathing practices – 3
Bhujangasana breathing, Ardha Shalabhasana breathing (alternate legs), Straight leg raising(alternate legs), Straight leg raising (both legs), Sethubandhasana lumbar stretch,
Instant Relaxation Technique (IRT)
Loosening Practices – 1
Shoulder Rotation, Side bending, standing twist, Hip rotation, Thigh strengtheningLoosening practices – 2
Chakki chalan, Bhunamasana Chalana, Alternative toe touchingLoosening practices – 3
Side leg raising, Pavana muktasana kriya: Wind releasing pose movements, Quick RelaxationTechnique (QRT)

UNIT VI

Asana practices – 1
Tadasana, Ardhakati Chakrasana, Ardha Chakrasana, Trikonasana,
VrikshasanaAsana practices – 2
Vakarasana, Janu Sirshasana, Ushtrasana,
Sashankasana,Asana practices – 3
Ardhamatseyndrasana, Paschimottanasana, Poorvottanasana,
GomukhasanaAsana practices – 4
Makarasana, Bhujangasana, Salambha Shalabahasana,
DhanurasanaAsana practices – 5
Setubandhasana, Sarvangasana, Mastyasana, Deep Relaxation
Technique (DRT)Soorya Namaskar
Pranayama – 1
Kapalbhati kriya and
Sectional Breathing
Pranayama – 2
Nadishuddhi
Pranayama
Pranayama –
3
Bhramari, Sheetali, Sitkari
and UjjayiOm 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. SwamiVivekananda Yoga Prakashana. 2011.
2. Contrada, R., & Baum, A. (Eds.). The handbook of stress science: Biology,psychology, and health. Springer Publishing 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. GuilfordPublications. 2021.
5. Swami Muktibodhananda, Hatha Yoga Pradipika, Bihar Scool of Yoga, 1998
6. Swami Satyananda Saraswati, Four Chapters on Freedom, Bihar Scool of Yoga, 1975
7. Swami Tapasyananda, Srimad Bhagavat Gita, Sri Ramakrishna Math, 2012

SEMESTER II

23U2901PC201	POWER SYSTEM DYNAMICS AND CONTROL	Credits 04

Pre-Requisites: Power system operation and control

Course Objective

To review fundamental aspects of dynamic systems and to illustrate the nature of small signal and transient stability problems, identifying factors influencing them. To present analyticaltechniques useful in the study of small signal and transient stability.

Course Outcome

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

CO1	Understand various models of Synchronous machine
CO2	Analyze SMIB performance for various conditions
CO3	Understand philosophy of power system stabilizer and their applications
CO4	Evaluate small signal stability analysis with and with out controller
CO5	Apply various small signal stability enhancement techniques.

Course Contents:

UNIT-I: Dynamics of Synchronous Generator Connected To Infinite Bus [7 Hours]

Review of Classical Methods System model, states of operation and system security, steady state stability, transient stability, simple representation of excitation control. System model, synchronous machine model, calculation of Initial conditions, system simulation, other machine models, inclusion of SVC model.

UNIT-II: Analysis of Single and Multi-Machine System [7 Hours]

Small signal analysis, applications of Routh-Hurwitz criterion, analysis of Synchronizing and damping torque, state equation for small signal model Simplified model, improved model of the system for linear load, Inclusion of dynamics of loadand SVC, introduction to analysis of large power system.

UNIT III: Power System Stabilizers [5 Hours]

Basic concepts of control signals in PSS, structure and tuning, field implementation andoperating experiences, example of PSS design and application, future trends.

UNIT-IV: Signal Stability Analysis without Controllers **[9 Hours]**

Classification of Stability, Basic Concepts and Definitions: Rotor angle stability, The Stability Phenomena. Fundamental Concepts of Stability of Dynamic Systems: Statespace representation, stability of dynamic system, Linearization, Eigen properties of the state matrix: Eigen values and eigenvectors, modal matrices, Eigen value and stability, mode shape and participation factor. Single-Machine Infinite Bus (SMIB) Configuration: Classical Machine Model stability analysis with numerical example, Effects of Field Circuit Dynamics: synchronous machine, network and linearized system equations, block diagram representation with K-constants; expression for K-constants (no derivation), effect of field flux variation on system stability: analysis with numerical example.

UNIT-V: Small-Signal Stability Analysis with Controllers **[8 Hours]**

Effects Of Excitation System: Equations with definitions of appropriate K-constants and simplethyristor excitation system and AVR, block diagram with the excitation system, analysis of effectof AVR on synchronizing and damping components using a numerical example, Power System Stabilizer: Block diagram with AVR and PSS, Illustration of principle of PSS application with numerical example, Block diagram of PSS with description, system state matrix including PSS,analysis of stability with numerical example.

UNIT-VI: Enhancement of Small Signal Stability[6 Hours]

Power System Stabilizer – Stabilizer based on shaft speed signal (delta omega) – Delta –P- Omega stabilizer-Frequency-based stabilizers – Digital Stabilizer – Excitation control design – Exciter gain – Phase lead compensation – Stabilizing signal washout stabilizer gain – Stabilizer limits

References:

1. Power System Dynamics and Stability, P. W. Sauer and M. A. Pai,, Stipes Publishing Co,2007
2. Dynamic Models for Steam and Hydro Turbines in Power System Studies,IEEE Committee Report, IEEE Trans., Vol.PAS-92, pp 1904-1915, November/December, 1973. on Turbine- Governor Model.
3. Power System Dynamics Analysis and Simulation, R.Ramunujam,PHI Learning Private Limited, New Delhi, 2009
4. Power System Stability and Control, P. Kundur,McGraw-Hill, 1993

23U2901PC202	ADVANCED POWER SYSTEM PROTECTION	Credits 04

Pre-Requisites: Switchgear and Protection

Course Objectives:-

- To understand various Optimization Techniques applicable in Power System and OptimalPower 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

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 relaysbasic 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, "TMHpublication New Delhi 1995.

REFERENCES:

1 Static relays, T.S.Madhava Rao, TMH publication, second edition 1989.

2. Protection and Switchgear, Bhavesh Bhalja, R. P. Mahesheari, Nilesh G. Chothani, OxfordUniversity Press.

3. Electrical Power System Protection, C. Christopoulos and A. Wright, Springer International

23U2901PE203A APOWER SECTOR ECONOMICS, REGULATION & RESTRUCTURING 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.

Course content:

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, utilitiesand 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 structuresand 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, Retailco, Power markettypes, 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, September2001, www.DravaSDune.org
3. Privatization or Democratization The Key to the Crises in the ElectricitySector - The Caseof 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 Electricityn, 2002, John Wiley Inc
9. Electric Utility Planning and Regulation, Edward Kahn, American Council for EnergyEfficient Economy
10. Market Operations in Electric Power Systems Forecasting, Scheduling and RiskManagement

23U2901PE203B	SMART GRID DESIGN AND ANALYSIS	03 Credits

Pre-Requisites: Power plant engineering, Power system operation

and control

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 into the grid, Creating a framework forknowledgeable 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	The various aspects of the smart grid.
CO2	Understand grid architecture design.
CO3	Understand various performance analysis tools for smart grid design.
CO4	Evaluate stability analysis for smart grid
CO5	Understand the integration of RES with smart grid and energy storage

Course contents:

UNIT-I: Introduction to Smart Grid [7 Hours]

What is Smart Grid? Working definitions of Smart Grid and Associated Concepts – Smart Grid Functions – Comparison of Traditional Power Grid and Smart Grid – New Technologies forSmart Grid – Advantages – Indian Smart Grid – Key Challenges for Smart Grid.

UNIT-II: Smart Grid Architectural Designs [7 Hours]

Smart grid – power system enhancement – communication and standards - General View of the Smart Grid Market Drivers - Stakeholder Roles and Function - Measures - Representative Architecture - Functions of Smart Grid Components-Wholesale energy market in smart grid- smart vehicles in smart grid.

UNIT-III: Smart Grid Communications and Measurement Technology [7 Hours]

Communication and Measurement - Monitoring, Phasor Measurement Unit (PMU), Smart Meters, Wide area monitoring systems (WAMS)- Advanced metering infrastructure- GIS and Google Mapping Tools.

UNIT-IV: Performance Analysis Tools For Smart Grid Design [7 Hours]

Introduction to Load Flow Studies - Challenges to Load Flow in Smart Grid and Weaknesses of the Present Load Fl ow Methods - Load Flow State of the Art: Classical, Extended Formulations,and Algorithms –Load flow for smart grid design-Contingencies studies for smart grid.

UNIT-V: Stability Analysis Tools For Smart Grid [7 Hours]

Voltage Stability Analysis Tools-Voltage Stability Assessment Techniquesoltage Stability Indexing-Application and Implementation Plan of Voltage Stability in smart grid-Angle stability assessment in smart grid-Approach of smart grid to State Estimation-Energy management in smart grid.

UNIT- VI: Renewable Energy and Storage **[7 Hours]**

Renewable Energy Resources-Sustainable Energy Options for the Smart Grid-Penetration and Variability Issues Associated with Sustainable Energy Technology-Demand Response Issues- Electric Vehicles and Plug-in Hybrids-PHEV Technology-Environmental Implications-Storage Technologies-Grid integration issues of renewable energy sources.

References Books:-

1) Smart Grid: Fundamentals of design and analysis, James Momoh John Wiley & sons Inc,IEEE press 2012.
2) Smart Grid: Technology and Applications,Janaka Ekanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, John Wiley & sons inc, 2012.
3) Smart Grid: Integrating Renewable, Distributed & Efficient Energy,Fereidoon P.Sioshansi, Academic Press, 2012.
4) The smart grid: Enabling energy efficiency and demand response,Clark W.Gellings,Fairmont Press Inc, 2009.

23U2901PE203C DISTRIBUTED GENERATION AND MICROGRID Credits 03

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

Course Objectives:- To understand various aspects of micrgrid design to meet the needs of autility viz Meeting a utility's objectives, Helping to adopt new technologies into the grid, Creating a framework for knowledgeable power engineers to operate the grid more effectivelyand 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.

Course content:

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 inDC 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 BOOS:

1. Power Switching Converters: Medium and High Power, Dorin Neacsu, CRC Press, Taylor & Francis,2006.
2. Solar Photo Voltaics, Chetan Singh Solanki, PHI learning Pvt. Ltd., New Delhi,2009.
3. Wind Energy Explained, theory design and applications,J.F. Manwell, J.G. McGowan Wileypublication,2002.
4. Biomass Regenerable Energy,D. D. Hall and R. P. Grover, John Wiley, New York, 1987. 6Renewable Energy Resources, John Twidell and Tony Weir, Tyalor and Francis Publications, 2005.

23U2901PCL206	**PG-LAB-III**	**Credits 04**

List of experiments:

Experiment 1: Analyse the steady-state stability of a power system by varying load conditions and assessing the system's ability to maintain equilibrium.

Experiment 2: Investigate the control strategies for HVDC converters and their impact on power system dynamics

Experiment 3: Load Flow Analysis Determine the voltage magnitude and phase angle at various buses in a power system using load flow analysis software.

Experiment 4: Transient Stability Analysis: Simulate a three-phase short circuit fault and analyse the transient behaviour of the power system

Experiment 5: Develop a dynamic model for a synchronous generator, including governor and excitation system models

Experiment 6: Load Shedding and Under-Frequency Relay Operation: Simulate a generation/transmission line outage and observe the operation of under-frequency relays

Experiment 7: Voltage Control and Reactive Power Compensation: Implement a voltage control scheme using on-load tap changers (OLTC) on transformers

Experiment 8: Dynamic Stability Studies: Simulate a disturbance, such as a sudden load change or generator tripping, and assess the system's dynamic stability

23U2901PCL207	PG-LAB-IV	Credits 04

List of experiments:

Experiment 1: To study the critical issues challenges before the Indian power sector

Experiment 2: To study different type methods of economic, regulation, regulatory process in India.

Experiment 3: To study power sector restacturing and market policy related issues in India.

Experiment 4: to study different types of tariff and Indian electricity act 2015

Experiment 5: Study of elecromecanical and numerical type IDMT over current relay

Experiment 6: Study of directional over current relay

Experiment 7: Study of earth fault relay

Experiment 8: Study of numerical type differential relay

SEMESTER III

23U2901PE301A APPLICATION OF POWER ELECTRONICS TO POWER SYSTEMS 03 Credits

Course Objectives:-

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

Unit 1 [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 **[7 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.Recent Publications on IEEE Journals

23U2901PE301B MODELING & SIMULATION OF POWER ELECTRONIC SYSTEM Credits 03

Course Objectives:-

1. To know the challenges, process, solution techniques for simulation
2. To make the students familiar to use state space techniques and SIMULINK tool tosimulate power electronics converters, electrical drives.
3. To model and design power electronics switching converters using state spaceaveraging technique.
4. To model and simulate impedance and converter based converters.

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

CO1	Understand and apply computer simulation process, challenges and technique modeling and simulation of power electronics converters.
CO2	Apply the state space modeling techniques for simulation of power electronic converters
CO3	Use the SIMULINK tool for simulation of various power electronics converters
CO4	Model and simulate the electrical drives and analyze the performance
CO5	Apply state space averaging technique to model power electronics converters
CO6	Model and simulate the FACT controllers.

Course contents:

UNIT.1. INTRODUCTION: **[4]**

Challenges in computer simulation - Simulation process - mechanics of simulation - Solutiontechniques for time domain analysis - Equation solvers - circuit-oriented simulators

UNIT-2. SIMULATION OF POWER ELECTRONIC CONVERTERS: **[8]**

State-space representation of power electronic converters (with buck converter as arepresentative example) - Trapezoidal integration - M & N method for simulating powerelectronic converters (with buck converter as a representative example) - Introduction toMATLAB and Simulink - Simulation of rectifiers - choppers and inverter circuits along withPWM techniques

UNIT.3. SIMULATION OF ELECTRIC DRIVES: [9]

Modeling of power electronic converters with transportation delay - Concept of control gain - linearization of rectifiers with inverse cosine control - State space model of 3-Ph IM - Principleof Vector control - Modeling and simulation of Vector controlled 3-Ph IM with a 3-level inverterdrive

UNIT.4. MODELING - SIMULATION OF SWITCHING CONVERTERS WITH STATE SPACE AVERAGING: [8]

State Space Averaging Technique– Modeling AND linearization of converter transfer functions -Simulation and Design of power electronic converters using State-space averaged models

Unit. 5. Modeling and simulation of impedance based compensators [8]

Modeling and analysis of series and shunt static Var Compensators:

Unit. 6. Modeling and simulation of converter based compensators. [9]

Modeling and Analysis of STATCOM, SSSC, UPFC.

References Books:

1.**:** *Simulation of Power Electronic Converters***,** M. B. Patil - V. Ramnarayanan, V. T.Ranganathan ,1st ed., Narosa Publishers, 2010

2. Power Electronics: Converters, Design and control, Ned Mohan, Undeland and Robbins**, -** 2nded., John Wiley

23U2901ES304	Environmental Studies	Credits 04

Course Objectives:

1. Provide students with a comprehensive understanding of key environmental concepts, principles, and challenges, enabling them to grasp the interconnectedness of ecologicalsystems 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

andpromote environmentally responsible behaviours 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 sourcesof 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 andproblems 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 Megadiversity 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 Quakes and Disaster Management, The Changing Nature of Earth

UNIT IV **[6Hr]**

Basics Of Municipal Solid Waste, Management of Municipal Solid Waste, Agony of Seas, ThePrice 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 RehabilitationEnvironment And Climate Change, Sex Ratio, Population Explosion, Impact of HumanPopulation 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. IGNOU 1995 – FST-1/4 Foundation course in Science and Technology "Environmentand Resource" - Indira Gandhi open university, New Delhi
4. Kothari Dr. Milind – 2005 – Environmental Education – Universal Publication, Agra.

23U2901PC305	Project-I	Credits 10

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.

SEMESTER IV

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.