`

HINDUSTAN
INSTITUTE OF TECHNOLOGY & SCIENCE
(DEEMED TO BE UNIVERSITY)

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

CURRICULUM AND SYLLABUS

Under CBCS

(Applicable for Students admitted from Academic Year 2018-19)

M. Tech. Power System Engineering

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

SCHOOL OF ELECTRICAL SCIENCES

HINDUSTAN INSTITUTE OF TECHNOLOGY & SCIENCE
VISION AND MISSION

VISION

To make every man a success and no man a failure.

MISSION

To provide every individual with a conducive environment suitable to achieve his / her career goals, with a strong emphasis on personality development, and to offer the academically inclined the resources to gain quality education in all spheres of engineering, applied sciences and management, without compromising the quality and code of ethics to each student of the Institution.

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
VISION AND MISSION

VISION

To educate the students in the recent developments of emerging fields in Electrical and Electronics Engineering, to encourage research activities, innovative techniques and to develop managerial abilities so as to make them excel globally

MISSION

- To enable the students to function as accomplished professionals in Electrical Engineering field with due emphasis on personality development and communication skills
- Students should develop the capacity to absorb new techniques and innovative ideas in modern technological environment.

M. Tech. Power System Engineering

PROGRAMME EDUCATIONAL OBJECTIVES (PEO)

The program is expected to enable the students to

PEO I Design and develop innovative products and services in the field of power system and engineering

PEO II keeps abreast with the latest technology and toolset.

PEO III Communicate effectively to propagate ideas and promote teamwork

PEO IV Attain intellectual leadership skills to cater to the changing needs of power industry, academia, society and environment

PROGRAM OUTCOMES (ALIGNED WITH GRADUATE ATTRIBUTES) (PO)

At the end of this program, graduates will be able to

PO1: An ability to apply knowledge of fundamentals of mathematics, science, and engineering.

PO2: An ability to identify, formulate and solve Electrical and Electronics Engineering problems.

PO3: An ability to understand and correctly interpret the impact of engineering solutions in a social/global context.

PO4: An ability to use research approaches for problem analysis and design.

PO5: An ability to skillfully use modern engineering tools and techniques necessary for engineering design, analysis and applications.

PO6: Ability to apply contextual knowledge relevant to professional engineering practices.

PO7: Understand the need for sustainable development and impact of professional engineering solutions in societal and environmental context.

PO8: Understanding of professional and ethical responsibility.

PO9: An ability to function and/or develop leadership in multi-disciplinary teams.

PO10: Ability to communicate effectively.

PO11: Ability to apply engineering and management principles to manage projects.

PO12: An ability to engage in life-long learning to follow developments in Electrical and Electronics Engineering.

PROGRAM SPECIFIC OUTCOMES (PSO)

PSO1: An ability to design and develop environmental friendly electrical Products

PSO2: To introduce application of electronics devices for conversion, control and automation

PSO3: Apply appropriate techniques and modern Engineering hardware and software tools inpower systems to engage in life- long learning and to successfully adapt in multi-disciplinary environments.

PSO4: Understand the impact of Professional Engineering solutions in societal and environmentalcontext, commit to professional ethics and communicate effectively.

M.TECH –POWER SYSTEM ENGINEERING									
(65 CREDIT STRUCTURE)									
SEMESTER - I									
SL. NO	**COURSE CATEGORY**	**COURSE CODE**	**NAME OF THE COURSE**	**L**	**T**	**P**	**C**	**S**	**TCH**
1	PC	MAA3705	Advanced Mathematics for Electrical Engineers	3	0	0	3	1	3
2	PC	EEB3701	Power System Planning And Reliability	3	0	0	3	1	3
3	PC	EEB3702	Advanced Power System Analysis	3	0	0	3	1	3
4	PC	EEB3703	Modeling and Analysis of Electrical Machines	3	0	0	3	1	3
5	PC	EEB3704	Electrical Transients in Power Systems	3	0	0	3	1	3
6	PC	ZZZ3715	Research Methodology & IPR	2	0	0	2	1	2
	PC	EEB3791	Power System Simulation Laboratory I	0	0	3	2	0	3
Total				**17**	**0**	**3**	**19**	**5**	**20**
SEMESTER – II									
SL. NO	**COURSE CATEGORY**	**COURSE CODE**	**NAME OF THE COURSE**	**L**	**T**	**P**	**C**	**S**	**TCH**
1	PC	EEB3705	Flexible AC Transmission Systems	3	0	0	3	1	3
2	DE		Department Elective – I	3	0	0	3	1	3
3	DE		Department Elective – II	3	0	0	3	1	3
4	DE		Department Elective – III	3	0	0	3	1	3
5	DE		Department Elective – IV	3	0	0	3	1	3
6	NE		Non Department Elective - I	3	0	0	3	1	3
7	PC	EEB3792	Power System Simulation Laboratory II	0	0	3	2	0	3
8	PC	EEB3796	Seminar	0	0	3	2	2	3
9	PC	EEB3780	Mini project	0	0	3	2	2	3
Total				**18**	**0**	**9**	**24**	**10**	**27**

M.TECH –POWER SYSTEM ENGINEERING									
(65 CREDIT STRUCTURE)									
SEMESTER – III									
SL. NO	**COURSE CATEGORY**	**COURSE CODE**	**NAME OF THE COURSE**	**L**	**T**	**P**	**C**	**S**	**TCH**
1	PC	EEB3797	Internship	0	0	3	2	2	3
2	PC	EEB3798	Project Phase –I	0	0	16	8	2	16
Total				**0**	**0**	**19**	**10**	**4**	**19**
SEMESTER – IV									
SL. NO	**COURSE CATEGORY**	**COURSE CODE**	**NAME OF THE COURSE**	**L**	**T**	**P**	**C**	**S**	**TCH**
1	PC	EEB3799	Project Phase –II	0	0	24	12	2	24
Total				**0**	**0**	**24**	**12**	**2**	**24**

LIST OF DEPARTMENTAL ELECTIVES WITH GROUPING - SEMESTER WISE									
SEM	COURSE CATEGORY	COURSE CODE	NAME OF THE COURSE	L	T	P	C	S	TCH
2	DE	EEB3721	Linear and Non-Linear Systems Theory	3	0	0	3	1	3
2	DE	EEB3722	Advanced Topics in Power Electronics	3	0	0	3	1	3
2	DE	EEB3723	Energy Storage Systems	3	0	0	3	1	3
2	DE	EEB3724	Electric and Hybrid Vehicles	3	0	0	3	1	3
2	DE	EEB3725	Distributed Generation And Micro-Grids	3	0	0	3	1	3
2	DE	EEB3726	Electrical Systems In Wind Energy	3	0	0	3	1	3
2	DE	EEB3727	Smart Grid Technologies& IOT	3	0	0	3	1	3
2	DE	EEB3728	Digital Simulation of Power Electronic Systems	3	0	0	3	1	3
2	DE	EEB3729	Power Quality	3	0	0	3	1	3
2	DE	EEB3730	Artificial intelligence in electrical drives	3	0	0	3	1	3
2	DE	EEB3731	Renewable Power Generation Technologies	3	0	0	3	1	3
2	DE	EEB3732	Energy Auditing And Management	3	0	0	3	1	3
2	DE	EEB3733	High Voltage DC Transmission	3	0	0	3	1	3
2	DE	EEB3734	Power System Automation	3	0	0	3	1	3

LIST OF NON DEPARTMENTAL ELECTIVES OFFERED BY ELECTRICAL DEPARTMENT WITH GROUPING - SEMESTER WISE									
SEM	COURSE CATEGORY	COURSE CODE	NAME OF THE COURSE	L	T	P	C	S	TCH
2	NE	EEB3741	Photovoltaic and fuel cell systems	3	0	0	3	1	3
2	NE	EEB3742	Wind and hydro energy systems	3	0	0	3	1	3
2	NE	EEB3743	Biomass energy systems	3	0	0	3	1	3

SEMESTER – I

COURSE TITLE	ADVANCED MATHEMATICS FOR ELECTRICAL ENGINEERS			CREDITS	3
Course Code	MAA3705	Course Category	PC	L-T-P-S	3- 0- 0- 1
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-3				

CO	COURSE OUTCOMES	PO
1	Gettingideaaboutbasicfundamentalsofprobability	1,2,4
2	Gettingideaaboutoptimizationtechniques	1,2,5
3	Gettingideaaboutdifferentialcalculus	1,2,12

Prerequisites : Nil

MODULE 1 – ADVANCEDMATRIXTHEORY(9L)

Matrixnorms–Jordancanonicalform–Generalizedeigenvectors–Singularvalue decomposition – Pseudo inverse – Least square approximations – QR algorithm

MODULE 2 – NUMERICAL SOLUTION OFALGEBRAICEQUATIONS(9L)

Solutions of large systems of equations using Gauss Elimination method; principle behind sparsity and optimal ordering; relevance of the solution technique for engineering applications.

MODULE 3 – NUMERICAL SOLUTION OF ORDINARYDIFFERENTIALEQUATIONS (9L)

Single and multi – step methods – explicit and implicit methods – advantages of implicit methods – solution of differential algebraic methods encountered in power engineering.

MODULE 4 – LINEARPROGRAMMING (9L)

Basic concepts – Graphical and Simplex methods –Transportation problem – Assignment problem.

MODULE 5 – DYNAMICPROGRAMMING(9L)

Elements of the dynamic programming model – optimality principle – Examples of dynamic programming models and their solutions.

REFERENCE BOOKS

1	Lewis.D.W., “Matrix Theory”, Allied Publishers,Chennai1995.
2	Bronson,R, “Matrix Operations”, Schaums outline Series ,McGraw Hill ,Newyork.1989.
3	L.O.Chua, P.M.Lin, “Computer-Aided Analsis of Electronic Circuits”, Prentice Hall, Englewood Cliffs, New Jersey,1978.
4	Taha, H.A., " Operations research - An Introduction ", Mac Millan publishing Co.,(1982).
5	Gupta, P.K.and Hira, D.S., "Operations Research", S.Chand& Co., NewDelhi,1999.

E BOOKS	
1	https://nptel.ac.in/downloads/111105035/
2	https://www.elsevier.com/books/mathematics-for-electrical-engineering-and-computing/attenborough/978-0-7506-5855-3
MOOC	
1	https://nptel.ac.in/courses/111105035/
2	http://www.nptelvideos.in/2012/11/mathematics.html
3	https://www.coursera.org/learn/seo-strategies

COURSE TITLE	POWER SYSTEM PLANNING AND RELIABILITY			CREDITS	3
COURSE CODE	EEB3701	COURSE CATEGORY	PC	L-T-P-S	3- 0- 0- 1
CIA	50%			ESE	50%
LEARNING LEVEL	BTL- 4				

CO	COURSE OUTCOMES	PO
1	To explain the characteristics of loads, concepts of load forecasting and its types for power system planning.	1,4,5
2	To comprehend the significance of reliability in power system, various methods and tools used for reliability analysis.	1,5
3	To describe the concepts of reliability in generation and transmission system, and system interconnection.	1,5,,12
4	To discriminate the different modes of system failure and to explain various approaches to assess power system failure	1, 9
5	Loss of load in power system will be analysed	1,12

Prerequisites : Power system analysis, Power system transmission and distribution

MODULE 1 – LOAD FORECASTING (9L)

Objectives of planning – Long and short term planning - Load forecasting – characteristics of loads – methodology of forecasting – energy forecasting – peak demand forecasting – total forecasting – annual
and monthly peak demand forecasting.

MODULE 2 – RELIABILITY ANALYSIS (9L)

Reliability concepts – exponential distributions – meantime to failure – series and parallel system – MARKOV process – recursive technique. Generator system reliability analysis – probability models for generators unit and loads – reliability analysis of isolated and interconnected system – generator system cost analysis – corporate model – energy transfer and off peak loading.

Suggested Reading: Different semiconductor devices can be studied

Applications: AC-DC Converter, DC-DC Converter, DC-AC Converter

MODULE 3 – TRANSMISSION RELIABILITY(9L)

Transmission system reliability model analysis – average interruption rate - LOLP method - frequency and duration method

Suggested Reading: Comparison of different converters

Applications: Renewable Energy Conversion

MODULE 4 – LOAD SYSTEM (9L)

Two plant single load system - two plant two load system - load forecasting uncertainly interconnections

benefits **Applications:** Domestic and Commercialapplications
MODULE 5 – SYSTEM MODES OF FAILURE (9L)
Introduction to system modes of failure – the loss of load approach – frequency & duration approach – spare value assessment – multiple bridge equivalents.
LAB / MINI PROJECT/FIELD WORK
Students should do the simulation of two plant two load system

	TEXT BOOKS
1	Sullivan, R.L., 'Power System Planning', Heber Hill, 1987.
REFERENCE BOOKS	
1	Roy Billington, 'Power System Reliability Evaluation', Gordan& Breach Scain Publishers,1990.
2	Eodrenyi, J., 'Reliability modelling in Electric Power System' John Wiley, 1980.
MOOC	
1	https://nptel.ac.in/courses/114106041/25
2	https://nptel.ac.in/courses/108105067/

COURSE TITLE	**ADVANCED POWER SYSTEM ANALYSIS**			**CREDITS**	**3**
COURSE CODE	**EEB3702**	**COURSE CATEGORY**	**PC**	**L-T-P-S**	**3- 0- 0- 1**
CIA	**50%**			**ESE**	**50%**
LEARNING LEVEL	**BTL- 3**				

CO	**COURSE OUTCOMES**	**PO**
1	To construct models of power system components and apply them	1,2,3
2	To solve ac and dc load flow for single and there phase systems	1,2,3
3	To analyse the faults in the power system networks	1,2,3,5
4	To apply the concepts of optimization in power system.	1,2,3
5	To explain the concept of state estimation in power system and the role of statistics in state estimation.	1,2,5,12

Prerequisites : Power System analysis
MODULE 1 – NETWORK MODELLING (9L)
Network modeling – Single phase and three phase modelling of alternators, transformers and transmissionlines, Conditioning of Y Matrix –- Incidence matrix method, Method of successive elimination, Triangularfactorization – Sparse matrix
MODULE 2 –LOAD FLOW ANALYSIS (9L)
Load flow analysis - Newton Raphson method, Fast Decoupled method, AC-DC load flow –Single and three phase methods – Sequential solution techniques and extension to multiple and multi-terminal DC systems.
MODULE 3 – FAULT ANALYSIS (9L)
Fault Studies -Analysis of balanced and unbalanced three phase faults – fault calculations – Short circuit faults – open circuit faults.
MODULE 4 –SYSTEM OPTIMIZATION (9L)
System optimization - strategy for two generator systems – generalized strategies – effect of

transmissionlosses - Sensitivity of the objective function - Formulation of optimal power flow-solution by Gradientmethod-Newton's method.

MODULE 5 – STATE ESTIMATION (9L)

State Estimation – method of least squares – statistics – errors – estimates – test for bad data – structure and formation of Hessian matrix – power system state estimation.

TEXT BOOKS

1	Grainger, J.J. and Stevenson, W.D. 'Power System Analysis' Tata McGraw hill, NewDelhi, 2003.
2	HadiSaadat, 'Power System Analysis', Tata McGraw hill, New Delhi, 2002.

REFERENCE BOOKS

1	Arrillaga, J and Arnold, C.P., 'Computer analysis of power systems' John Wiley and Sons, New York, 1997.
2	Pai, M.A., 'Computer Techniques in Power System Analysis', Tata McGraw Hill, New Delhi, 2006

E BOOKS

1	https://easyengineering.net/power-systems-books/

MOOC

1	https://nptel.ac.in/courses/111107105/8

COURSE TITLE	MODELLING AND ANALYSIS OF ELECTRICAL MACHINES			CREDITS	3
COURSE CODE	EEB3703	COURSE CATEGORY	DE	L-T-P-S	3- 0- 0- 1
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-4				

CO	COURSE OUTCOMES	PO
1	To understand the principle of electromagnetic energy conversion.	1,2,3
2	To understand the basic concepts of rotating machines and to derive the torque and voltage equation for DC motor.	1,2,3
3	To represent the dynamic model of three phase induction motor in arbitrarily rotating reference frame.	1,2,3
4	To analyze the dynamic performance of two phase asymmetrical induction machine and single phase induction machine.	1,2,3,5
5	To analyze the dynamic performance of permanent magnet synchronous motor and switched reluctance motor.	1,2,3,12

Prerequisites : Electromagnetic field theory, Vector algebra and fundamentals of all electrical rotating machines

MODULE 1-ELECTROMECHANICAL ENERGY CONVERSION (9L)

Principles of Electromagnetic Energy Conversion, General expression of stored magnetic energy, co-energy and force/torque, example using single and doubly excited system.

Suggested Reading: Modelling and simulation for self-excited doubly salient retarder system using MATLAB.

Applications: Electrostatic actuators, dielectric actuators

MODULE 2-BASIC PRINCIPLE OF DC MACHINES (9L)

Basic Concepts of Rotating Machines-Calculation of air gap mmf and per phase machine inductance using physical machine data; Voltage and torque equation of dc machine.

Suggested Reading: Sensorless speed control of DC motor using MATLAB

Applications: Space operated vehicles, electric aircraft.

MODULE 3-MODELING OF AC MACHINES (9L)

Three phase symmetrical induction machine and salient pole synchronous machines in phase variable form; Application of reference frame theory to three phase symmetrical induction and synchronous machines, dynamic direct and quadrature axis model in arbitrarily rotating reference frames.
Suggested Reading: Steady-state modelling and analysis of synchronous motor using MATLAB.
Applications: Phonograph turntables, Constant speed constant load drives.

MODULE 4-DYNAMIC ANALYSIS OF AC MACHINES (9L)

Determination of Synchronous Machine Dynamic Equivalent Circuit Parameters, Analysis and dynamic modeling of two phase asymmetrical induction machine and single phase induction machine.
Suggested Reading: Field Oriented Control of Induction Motors using Symmetrical Optimum Method
Applications: Hybrid electric vehicles, linear actuators.

MODULE 5-DYNAMIC ANALYSIS OF SPECIAL MACHINES (9L)

Special Machines - Permanent magnet synchronous machine: Surface permanent magnet (square and sinusoidal back emf type) and interior permanent magnet machines. Construction and operating principle, dynamic modeling and self-controlled operation; Analysis of Switch Reluctance Motors.
Suggested Reading: Modelling and Simulation of Switched Reluctance Motor using MATLAB
Applications: Hybrid electric vehicles, power generation from Ocean Waves by Engine for Producing Energy from Sea Waves (EPEW).

LAB / MINI PROJECT/FIELD WORK

Vector Control of Permanent Magnet Synchronous Motor using MATLAB

TEXT BOOKS

1	Paul Krause, Oleg Wasynczuk, Scott D. Sudhoff, Steven Pekarek, Analysis of Electric Machinery and Drive Systems, 3rd Edition, Wiley-IEEE Press, 2013.
2	C V Jones, The unified theory of electrical machines, London: Butterworths, 2003.
3	Peter Vas, Vector control of AC machines, Clarendon press, 2001.

REFERENCE BOOKS

1	J. Murphy, F. G. Turnbull, Power Electronic Control of AC Motors, 1st Edition, Franklin Book Co, 2003.
2	R. Krishnan, 'Electric Motor & Drives: Modeling, Analysis and Control', Prentice Hall of India, 2nd Edition, 2001.
3	Miller, T.J.E., 'Brushless Permanent Magnet and Reluctance Motor Drives', Clarendon Press, 1st Edition, 2001.
4	Charles Kingsley, Jr., A.E. Fitzgerald, Stephen D.Umans, 'Electric Machinery', Tata McGraw-Hill, 5th Edition, 2002.

E BOOKS

1	https://ieeexplore.ieee.org/xpl/bkabstractplus.jsp?reload=true&bkn=5265638
2	http://een.iust.ac.ir/profs/Arabkhabouri/Electrical%20Drives/Books/Rik%20De%20Doncker,%20Duco%20W.J.%20Pulle,%20Andre%20Veltman-Advanced%20Electrical%20Drives_%20Analysis,%20Modeling,%20Control%20(Power%20Systems)-Springer%20(2011).pdf

MOOC

1	https://nptel.ac.in/courses/108106023/
2	https://freevideolectures.com/course/3527/modelling-and-analysis-of-electric-machines
3	https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-685-electric-machines-fall-2013/
4	http://www.myopencourses.com/subject/modeling-and-analysis-of-electric-machines

COURSE TITLE	**ELECTRICAL TRANSIENTS IN POWER SYSTEMS**			**CREDITS**	**3**
COURSE CODE	**EEB3704**	**COURSE CATEGORY**	**PC**	**L-T-P-S**	**3- 0- 0- 1**
CIA	**50%**			**ESE**	**50%**
LEARNING LEVEL	**BTL-5**				

CO	**COURSE OUTCOMES**	**PO**
1	To know about high voltage transient Behavior travelling on line	1,2,3
2	To get knowledge about voltage solutions under transient conditions using lattice diagram	1,2,3
3	To get knowledge about lightning and switching voltage travelling behavior using EMTP	1,2,3
4	To get knowledge about insulation coordination under transients	1,2,3,12
5	To get knowledge about high voltage Transient behavior travelling on line.	1,2,3,12

Prerequisites : Analog, digital and Power electronic circuits.

MODULE 1 – TRAVELLING WAVES ON TRANSMISSION LINE(9L)

Principle of digital computation - Matrix method of solution, Modal analysis, transforms, Computation using EMTP - Simulation of switches and non-linear elements.

MODULE 2 – COMPUTATION OF POWER SYSTEM TRANSIENTS(9L)

Principle of digital computation - Matrix method of solution, Modal analysis, transforms, Computation using EMTP - Simulation of switches and non-linear elements.

MODULE 3- LIGHTNING, SWITCHING AND TEMPORARY OVERVOLTAGES(9L)

Lightning: Physical phenomena of lightning - Interaction between lightning and power system - Factors contributing to line design - Switching: Short line or kilometric fault - Energizing transients – closing and re-closing of lines - line dropping, load rejection - Ferro resonance-Double frequency transients, Voltage induced by fault - Very Fast Transient Overvoltage (VFTO)

MODULE 4 –BEHAVIOUR OF WINDING UNDER TRANSIENT CONDITION (9L)

Initial and Final voltage distribution - Winding oscillation - traveling wave solution - Behaviour of the transformer core under surge condition - Rotating machine - Surge in generator and motor

MODULE 5 –INSULATION CO-ORDINATION(9L)

Principle of insulation co-ordination in Air Insulated substation (AIS) and Gas Insulated Substation (GIS), insulation level, statistical approach, co-ordination between insulation and protection level - overvoltage protective devices –types ofsurgediverters-lightning arresters, substation earthing.

TEXT BOOKS	
1	PritindraChowdhari, "Electromagnetic transients in Power System", John Wiley and Sons Inc., 1996.
2	Allan Greenwood, "Electrical Transients in Power System", Wiley & Sons Inc. New York, 1991
REFERENCE BOOKS	
1	Naidu M S and Kamaraju V, "High Voltage Engineering", Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004
2	Rakosh Das Begamudre, "Extra High Voltage AC Transmission Engineering", (Second edition) Newage International (P) Ltd., New Delhi, 1990.
E BOOKS	
1	Dr. Allan Greenwood , “ELECTRICAL TRANSIENTS IN POWER SYSTEMS”, ISBN: 978-0-471-62058-7 April 1991 768 Pages
MOOC	
1	https://nptel.ac.in/courses/108104051/9
2	https://nptel.ac.in/courses/108104051/10

COURSE TITLE	**RESEARCH METHODOLOGY & IPR**				**CREDITS**	**2**
COURSE CODE	**ZZZ3715**	**COURSE CATEGORY**	**PC**	**L-T-P-S**	**2-0-0-0**	
CIA	**50%**			**ESE**	**50%**	
LEARNING LEVEL	**BTL-5**					

CO	**COURSE OUTCOMES**	**PO**
1.	Understand research problem formulation.	1,2,3
2.	Understand that today’s world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.	1,2,3
3.	Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.	1,2,3,5
4.	Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.	1,2,3,5
5.	Analyze research related information and to follow research ethics	1,2,3,12

Prerequisites: Nil

MODULE 1 – RESEARCH PROBLEM FORMULATION (9L)

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

MODULE 2 –RESEARCH PROPOSAL AND ETHICS (9L)

Effective literature studies approaches, analysis Plagiarism, Research ethics, Effective technical

writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.	
MODULE 3 - DATA ANALYSIS AND INTERPRETATION (9L)	
Classification of Data, Methods of Data Collection, Sampling, Sampling techniques procedure and methods, Ethical considerations in research Data analysis, Statistical techniques and choosing an appropriate statistical technique, Hypothesis, Hypothesis testing, Data processing software (e.g. SPSS etc.), statistical inference, Interpretation of results.	
MODULE 4 - NATURE OF INTELLECTUAL PROPERTY (9L)	
Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.	
MODULE 5 –PATENT RIGHTS AND NEW DEVELOPMENTS IN IPR (9L)	
Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.	
REFERENCE BOOKS	
1	Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students’,
2	Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”
3	Ranjit Kumar, 2 nd Edition, “Research Methodology: A Step by Step Guide for beginners”
4	Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.
5	Mayall , “Industrial Design”, McGraw Hill, 1992.
6	Niebel , “Product Design”, McGraw Hill, 1974.
7	Asimov, “Introduction to Design”, Prentice Hall, 1962.
8	Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological Age”, 2016.
9	T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008
10	C.R. Kothari, Gaurav Garg, Research Methodology Methods and Techniques , New Age International publishers, Third Edition
11	Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, 2nd Edition, SAGE, 2005
12	Business Research Methods – Donald Cooper & Pamela Schindler, TMGH, 9th edition
13	Creswell, John W. Research design: Qualitative, quantitative, and mixed methods, approaches. Sage publications, 2013.

Course Title	DESIGN AND SIMULATION OF POWER SYSTEM SIMULATION I LABORATORY				2
Course Code	EEB3791	Course Category	PC	L-T-P-S	0-03-0
CIA	60%		ESE	40%	
LEARNING LEVEL	BTL-4				

CO	COURSE OUTCOMES	PO
1	Determine under-utilization of systemresources	1,3,4,5
2	View & analyze initial & post-disturbance actions	1,3,4,5,12
3	Design more efficient & reliable power systems	1,3,4,5,12

Prerequisites: -: Basic Power System

Practical:	**(45)**

1. Power flow analysis by Newton-Raphson method and Gauss-seidal method.
2. Power flow analysis by Fast decoupled method
3. Unit commitment: Priority-list schemes and dynamic programming
4. Economic dispatch using lambda-iteration method
5. Analysis of switching surge:Energization of a long distributed-parameter line
6. Transient stability analysis of single machine-infinite bus system using classical machine model
7. Co-ordination of over-current and distance relays for radial line protection
8. Digital Over Current Relay Setting and Relay Coordination.
9. Reliability Assessment on Power system.

SEMESTER – II

COURSE TITLE	FLEXIBLE AC TRANSMISSION SYSTEMS		CREDITS	3
COURSE CODE	EEB3705	COURSE CATEGORY	L-T-P-S	3- 0- 0- 1
CIA	50%		ESE	50%
LEARNING LEVEL	BTL- 5			

CO	COURSE OUTCOMES	PO
1	Identify the conditions in conventional power system where the installation of FACTS controllers or Devices becomes vital.	2,3,4,5,12
2	Analyze the performance of a conventional transmission system and apply the principles of reactive power compensation for improvement.	2,3,4,5,12
3	Illustrate the modes of operation of thyristor based and voltage source converter based FACTs controllers and explain the capabilities and modeling aspects.	2,3,4,5,12

4	Analyze different series, shunt or combined series-shunt FACTs controllers and compute the performance when installed in a given transmission system.	2,3,4,5,12
5	Analyze the different modes of operation of UPFC.Comparinf the performance of UPFC with other FACTS controllers	2,3,4,5,12

Prerequisites : Power System Analysis, Power Conversion techniques or equivalent

Module 1 - INTRODUCTION (9L)

Fundamentals of ac power transmission - transmission problems and needs - emergence of FACTS - FACTS control considerations - FACTS controllers

Suggested Reading: EVHAC lines

Applications: Transmission Line

Module 2 - STATIC VAR COMPENSATOR (SVC) (9L)

Principles of shunt compensation – Variable Impedance type & switching converter type - Static Synchronous Compensator (STATCOM) configuration - characteristics and control

Applications: Improve the performance of transmission Line

Module 3 - THYRISTOR CONTROLLED SERIES CAPACITOR (TCSC) AND APPLICATIONS (9L)

Principles of static series compensation using GCSC, TCSC and TSSC – applications - Static Synchronous Series Compensator (SSSC)

Suggested Reading: Place of adding series compensators in transmission lines

Applications: Series compensators in transmission lines

Module 4 - VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS (9L)

Principles of operation - Steady state model and characteristics of a static voltage regulators and phase shifters - power circuit configurations

Suggested Reading: Need for VSC's

Applications: Transmission Lines

Module 5 - UNIFIED POWER FLOW CONTROLLER (9L)

UPFC - Principles of operation and characteristics - independent active and reactive power flow control- comparison of UPFC with the controlled series compensators and phase shifters

Suggested Reading: UPFC control

Applications: Reactive and Real power compensation in Transmission Lines

TEXT BOOKS

1	Song, Y.H. and Allan T. Johns, 'Flexible AC Transmission Systems (FACTS)', Institution of Electrical Engineers Press, London, 1999.
2	Hingorani ,L.Gyugyi, 'Concepts and Technology of Flexible AC Transmission System', IEEE Press New York, 2000 ISBN –078033 4588.

REFERENCE BOOKS

1	Mohan Mathur R. and Rajiv K.Varma , 'Thyristor - based FACTS controllers for Electrical transmission systems', IEEE press, Wiley Inter science , 2002.
2	Padiyar K.R., 'FACTS controllers for Transmission and Distribution systems' New Age International Publishers, 1st Edition, 2007.
3	Enrique Acha, Claudio R.Fuerte-Esqivel, Hugo Ambriz-Perez, Cesar Angeles-Camacho 'FACTS – Modeling and simulation in Power Networks' John Wiley & Sons, 2002

E BOOKS

1	www.engineeringbookspdf.com/thyristor-based-facts-controllers-electrical-transmissio.

2	http://www.engineeringbookspdf.com/understanding-facts-concepts-and-technology-of-flexible-ac-transmission-systems-by-narain-g-hingorani-and-laszlo-gyugyi/
MOOC	
1	https://onlinecourses.nptel.ac.in/noc18_ee44
2	ictd.ae/en/courses/details/8728

ELECTIVES

COURSE TITLE	**LINEAR AND NON-LINEAR SYSTEMS THEORY**			**CREDITS**	**3**
COURSE CODE	**EEB3721**	**COURSE CATEGORY**	**PC**	**L-T-P-S**	**3- 0- 0- 1**
CIA	**50%**			**ESE**	**50%**
LEARNING LEVEL	**BTL- 4**				

CO	**COURSE OUTCOMES**	**PO**
1	Understand and model physical systems using state vectors	2,3,
2	Analyze the stability of linear systems.	2,3,
3	Design state feedback controllers and observers.	2,3,4,5
4	Understand and analyze non-linear systems using linear approximations.	3,4,5,12
5	Inspect the stability of non-linear systems by direct and indirect methods.	3,4,5,12

Prerequisites : control system

MODULE 1 STATE SPACE REPRESENTATION (9L)

Introduction to state space modeling, modelling of physical systems. Solution to vector differential equations and state transition matrix.

Suggested Reading: Modelling of different Electrical and Mechanical systems

MODULE 2 – CONTROLLABILITY AND OBSERVABILITY (9L)

Stability analysis of linear systems. Controllability and Observability definitions and Kalman rank conditions. Detectability and Stabilizability, Kalman decomposition.

Suggested Reading: Analysis of Multi input Multi output systems

MODULE 3 – MODAL CONTROL (9L)

State feedback controller design using pole placement. Observer design using Kalman filter algorithm. LQR and LQG controller design

Suggested Reading: Pole placement by feedback for multi input systems

MODULE 4 NONLINEAR SYSTEMS (9L)

Introduction to nonlinear systems. Phase plane analysis of nonlinear system using linear approximation.Limit cycle and periodic solutions. Singular points (equilibrium points) and qualitative behavior near singular points.

Suggested Reading: Types of nonlinearity

MODULE 5 – STABILITY (9L)

Stability of nonlinear systems. Lyapunov direct and indirect methods. Input-to-state stability and relative stability

Suggested Reading: Aids to finding Lyapunov function for Nonlinear continuous time autonomous system

TEXT BOOKS

1	M. Gopal, "Modern Control System Theory", New Age International, 2009.
2	K. Ogatta, "Modern Control Engineering", PHI, 2010.
3	D. Roy Choudhury, "Modern Control Systems", New Age International, 2005.

4	Z. Bubnicki, "Modern Control Theory", Springer, 2005.
REFERENCE BOOKS	
1	C.T. Chen, 'Linear Systems Theory and Design', Oxford University Press, 3rd Edition, 1999.
2	M. Vidyasagar, 'Nonlinear Systems Analysis', 2nd edition, Prentice Hall, Englewood Cliffs, New Jersey 07632.
3	Hassan K. Khalil, 'Nonlinear Systems', Pearson Educational International Inc. Upper Saddle River, 3rd Edition.
E BOOKS	
1	M. Gopal, "Modern Control System Theory",Halsted Press New York, NY, USA
2	https://www.mathworks.com/support/books/modern-control-systems-dorf.html
MOOC	
1	https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-243j-dynamics-of-nonlinear-system
2	http://inis.jinr.ru/sl/tot_ra/0/0/3/Rugh-Nonlin.pdf

COURSE TITLE	**ADVANCED TOPICS IN POWER ELECTRONICS**			**CREDITS**	**3**
COURSE CODE	**EEB3722**	**COURSE CATEGORY**	**DE**	**L-T-P-S**	**3- 0- 0- 1**
CIA	**50%**			**ESE**	**50%**
LEARNING LEVEL	**BTL-4**				

CO	**COURSE OUTCOMES**	**PO**
1	Understand the principles of operation of advanced Silicon devices.	2,3,
2	Appraise various advanced converter topologies and the suitable control schemes.	2,3,
3	Recognize recent developments in design aspects of reactive elements such as the material, the structure etc and the effect on performance.	2,3,4
4	Understand nuances of advanced energy storage systems such as battery energy storage system (BESS), ultra-capacitors, etc and strategies for power management in such systems.	4,5,12
5	Distinguish between various possible solutions pertaining to thermal management and EMI/EMC problems and devise solutions for simple power electronic systems	3,4,5,12

Prerequisites: Power Electronics.

MODULE 1 – POWER SEMICONDUCTOR DEVICES (9L)

Introduction to switches - Advanced Silicon devices - Silicon HV thyristors, MCT, BRT & EST. SiC devices - diodes, thyristors, JFETs & IGBTs. Gallium nitrate devices - Diodes, MoSFETs

MODULE 2 – ADVANCED CONVERTER (9L)

Advance converter topologies for PEE - Interleaved converters, Z-Source converters, Multi level converters (Cascaded H-Bridge, Diode clamped, NPC, Flying capacitor) Multi pulse PWM current

source converters, Advanced drive control schemes.

MODULE 3 – REACTIVE ELEMENTS (9L)

Advances in reactive elements - Advanced magnetic material, technology and design (Powder ferrite, Amorphous, Planar designs) Advance capacitive designs (Multilayer chip capacitors, double layers for storage, Aluminum electrolytic)

MODULE 4 – STORAGE SYSTEMS (9L)

Advance storage systems - Developments in battery systems, Ultra capacitors, Fly wheel energy storage, Hybrid storage systems for EV/HEV, Power management in hybrid systems, Energy storage in renewable.

MODULE 5 – THERMAL ENGINEERING (9L)

Thermal engineering with EMI/EMC techniques - Advanced thermal solutions (fan cooled, liquid cooled, heat pipes, hybrid techniques) EMC techniques (Conducted, Radiated emissions & Susceptibility), System design for EMC.

TEXT BOOKS

1	Andrzej M Trzynadlowski, 'Introduction to Modern Power Electronics, John Wiley and sons. Inc, New York, 1998
2	R D MiddleBrook& Slobodan CUK, 'Advances in Switched Mode Power Conversion', Vol I, II, & III, Tesla Co(optimum power conversion)

REFERENCE BOOKS

1	B. JayantBalinga, 'Advanced High Voltage Power Device Concepts', Springer New York 2011. ISBN 978 -1-4614-0268-8
2	BIN Wu, ' High Power Converters and AC Drives', IEEE press Wiley Interscience, a John wiley& sons Inc publication 2006
3	Wurth Electronics, 'Trilogy of Magnetics, Design guide for EMI filter design in SMPS & RF circuits', 4th extended and revised edition.

E BOOKS

1	http://engineeringbookspdf.com/download/2017/11/231117/Introduction%20to%20Modern%20Power%20Electronics%20Third%20Edition%20By%20Andrzej%20M%20Trzynadlowski.pdf

MOOC

1	https://www.coursera.org/learn/converter-circuits
2	https://nptel.ac.in/courses/nptel_download.php?subjectid=108101038

COURSE TITLE	ENERGY STORAGE SYSTEMS			CREDITS	3
COURSE CODE	EEB3723	COURSE CATEGORY	DE	L-T-P-S	3- 0- 0- 1
CIA	50%			ESE	50%
LEARNING LEVEL	BTL- 4				

CO	COURSE OUTCOMES	PO
1	Recognize various issues related to energy market, its growth and its structural implications in India.	2,3

2	Analyze the performance of different battery storage systems.	2,3,
3	Employ different thermoelectric measurement techniques appropriately.	2,3,4
4	Interpret the applications of super capacitors for appropriate storage systems.	2,3,4,5,12
5	Understand and differentiate different types of fuel cells.	3,4,5,12

Prerequisites : Fundamental Chemistry and Material Science.

MODULE 1 – INTRODUCTION (9L)

Prospect for both traditional and renewable energy sources - detailed analysis of Indian energy market and future need through 2020 - energy, economic growth and the environment, implications of the Kyoto Protocol, and structural change in the electricity supply industry

Suggested Reading: Present and Future Energy Scenario in India

MODULE 2 – STORAGE SYSTEMS (9L)

Batteries - performance, charging and discharging, storage density, energy density, and safety issues, classical batteries - Lead Acid, Nickel-Cadmium, Zinc Manganese dioxide, and modern batteries -Zinc-Air, Nickel Hydride, Lithium Battery.

Suggested Reading : Storage Battery Maintenance and Principles

MODULE 3 – THERMOELECTRIC (9L)

Thermoelectric - electron conductor and phonon glass, classical thermoelectric materials (i) four-proberesistivity measurement, Seebeck coefficient measurement, and thermal conductivity measurement.

Suggested Reading:

Applications:

MODULE 4 – SUPER CAPACITORS (9L)

Super capacitors - types of electrodes and some electrolytes, Electrode materials - high surface area activated carbons, metal oxide, and conducting polymers, Electrolyte - aqueous or organic, disadvantages and advantages of super capacitors - compared to battery systems, applications - transport vehicles, private vehicles, and consumer electronics - energy density, power density, price, and market.

Suggested Reading: Linden's Handbook of Batteries, Fourth Edition by by: Thomas B. Reddy

MODULE 5 – FUEL CELLS (9L)

Fuel cells - direct energy conversion - maximum intrinsic efficiency of an electrochemical converter, physical interpretation - carnot efficiency factor in electrochemical energy convertors, types of fuel cells -hydrogen oxygen cells, hydrogen air cell, alkaline fuel cell, and phosphoric fuel cell.

Suggested Reading: fuel cells and its application

TEXT BOOKS

1	Tetsuya Osaka, MadhavDatta, 'Energy Storage Systems in Electronics', Gordon and Breach Science Publishers, 2000.
2	R. M. Dell, D.A.J. Rand, 'Understanding Batteries', RSC Publications, 2001.

REFERENCE BOOKS

1	James Larminie, Andrew Dick, 'Fuel Cell System Explained', J. Wiley, 2003.
2	D.M. Rowe, 'Thermoelectrics Handbook: Macro to Nano', CRC Press, 2006.

E BOOKS

1	https://ocw.tudelft.nl/wp-content/uploads/Sustainable-hydrogen-and-electrical-energy-storage-lecture1.pdf

MOOC

1	https://ocw.tudelft.nl/course-lectures/introduction-energy-storage/

2	https://ocw.tudelft.nl/courses/sustainable-hydrogen-electrical-energy-storage/

COURSE TITLE	**ELECTRIC AND HYBRID VEHICLES**			**CREDITS**	**3**
COURSE CODE	**EEB3724**	**COURSE CATEGORY**	**DE**	**L-T-P-S**	**3- 0- 0- 1**
CIA	**50%**			**ESE**	**50%**
LEARNING LEVEL	**BTL- 4**				

CO	**COURSE OUTCOMES**	**PO**
1	Understand mathematical models, performance and characteristics of hybrid and electric vehicles.	2,3,4
2	Analyze the concepts, topologies and power flow control of electric traction systems.	2,3,4
3	Appraise the configuration and control of various hybrid electric motor drives	2,3,4,5
4	Plan and design appropriate vehicle management system.	2,3,4,5,12

Prerequisites : power electronics

MODULE 1 – INTRODUCTION HYBRID AND ELECTRIC VEHICLES (9L)

History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance.

Suggested Reading: Future prospectus of hybrid and electric vehicles

Applications: Modern hybrid vehicles

MODULE 2 – ELECTRIC TRACTION SYSTEMS(9L)

Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. Basic concepts of electric traction, introduction to various electric drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.

Suggested Reading: https://link.springer.com/chapter/10.1007/978-3-642-30281-7_2 (Railway traction system)

MODULE 3 – HYBRID ELECTRIC MOTOR DRIVES(9L)

Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Introduction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

Suggested Reading: Modern Electric Hybrid Electric & Fuel Cell Vehicles by MehrdadEhsani (http://ceb.ac.in/knowledge-center)

MODULE 4 –ELECTRICAL MACHINES AND INTERNAL COMBUSTION ENGINE(9L)

Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems.

Suggested Reading: Selection of ICE and Electrical machines

MODULE 5 – VEHICLE MANAGEMENT SYSTEM(9L)

Introduction to energy management strategies used in hybrid and electric vehicle, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy strategies. **Suggested Reading: Advanced Vehicle Management System**	
LAB / MINI PROJECT/FIELD WORK	
TEXT BOOKS	
1	Sira -Ramirez, R. Silva Ortigoza, 'Control Design Techniques in Power Electronics Devices', Springer, 2006
2	Siew-Chong Tan, Yuk-Ming Lai, Chi Kong Tse, 'Sliding mode control of switching Power Converters', CRC Press, 2011
REFERENCE BOOKS	
1	Bimal Bose, 'Power electronics and motor drives', Elsevier, 2006
2	Ion Boldea and S.A Nasar, 'Electric drives', CRC Press, 2005
E BOOKS	
1	https://www.elsevier.com/books/electric-and-hybrid-vehicles/pistoia/978-0-444-53565-8 (**eBook ISBN:** 9780444535665)
2	https://onlinelibrary.wiley.com/doi/book/10.1002/9781119998914 Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives
MOOC	
1	https://www.edx.org/course/electric-cars-introduction
2	https://www.edx.org/course/hybrid-vehicles

COURSE TITLE	**DISTRIBUTED GENERATION AND MICRO-GRIDS**			**CREDITS**	**3**
COURSE CODE	**EEB3725**	**COURSE CATEGORY**	**DE**	**L-T-P-S**	**3- 0- 0- 1**
CIA	**50%**			**ESE**	**50%**
LEARNING LEVEL	**BTL-4**				

CO	**COURSE OUTCOMES**	**PO**
1	Understand the current scenario of Distributed Generation and the need to implement DG sources.	2,3,4
2	Investigate the different types of RES as DGs.	2,3,4
3	Appraise the grid integration ,interfaces and technical impacts of DGs upon transmission and distribution systems	2,3,4,5
4	Analyze the aspects of Power Quality and Reliability.	3,4,5,12
5	To understand comprehensively about different types of Storage systems.	3,4,5,12

Prerequisites : The students are preferred to have a basic knowledge in Power System Analysis and DistributionSystems

MODULE 1 – INTRODUCTION , PLACING AND SIZING THE DISTRIBUTED ENERGY RESOURCES (9L)
Need for Distributed generation, renewable sources in distributed generation, current scenario in Distributed Generation, Planning of DGs – Siting and sizing of DGs – optimal placement of DG sources in distribution systems.

Suggested Reading: Detailed study of Renewable Energy Sources **Applications:** Siting and Sizing of DGs using ETAP	
MODULE 2 –RENEWABLE ENERGY SOURCES	**(9L)**
Wind Power-Photovoltaic and Thermo-solar power-Biomass Power, Fuel cells types, types of Tidal power generation schemes, mini and micro hydro power schemes. **Suggested Reading**: Micro turbines for DG, bulb and tubular turbines-	
MODULE 3 –GRID INTEGRATION , INTERFACES AND IMPACTS OF DGS .	**(9L)**
Grid integration of DGs – Different types of interfaces - Inverter based DGs - Aggregation of multiple DG units. – Transmission systems, Distribution systems, De-regulation – Impact of DGs upon protective relaying **Suggested Reading:**Rotating machine based interfaces	
MODULE 4 – POWER QUALITY AND RELIABILITY IN DER	**(9L)**
Voltage control techniques, Reactive power control, Harmonics, Power quality issues. Reliability of DG based systems – Steady-state and Dynamic analysis. **Suggested Reading:** Various aspects of Operations	
MODULE 5 –ENERGY STORAGE AND CONTROL TECHNIQUES(9L)	
Energy Storage for use with Distributed Generation-Battery Storage, Capacitor Storage, ultra-capacitors and Mechanical Storage: Flywheels, Pumped and Compressed Fluids. Control Techniques for DER integration systems- Standards and codes for interconnection- future structure of grid. **Suggested Reading:** Various aspects such as Market Management Retailing , Trading and Ancillary Services	
LAB / MINI PROJECT/FIELD WORK	
Simulation in ETAP/HOMER	
TEXT BOOKS	
1	"Distributed Power Generation, Planning & Evaluation" by H. Lee Willis & Walter G. Scott, 2000 Edition, CRC Press Taylor & Francis Group.
2	"Renewable energy power for a sustainable future" by Godfrey Boyle ,2004 Oxford University Press in association with the Open university.
3	Godoy Simoes, Felix A.Farret, 'Renewable Energy Systems – Design and Analysis with Induction Generators', CRC press.
4	Robert Lasseter, Paolo Piagi, ' Micro-grid: A Conceptual Solution', PESC 2004, June 2004.
REFERENCE BOOKS	
1	Z. Ye, R. Walling, N. Miller, P. Du, K. Nelson 'Facility Microgrids', Subcontract report, May 2005,
2	Mohammad Shahidehpour, M. Alomoush, Restructured Electrical Power Systems: Operation: Trading, and Volatility, CRC Press, 2001
3	N. Jenkins, J.B. Ekanayake and G. Strbac, Distributed Generation, The Institution of Engineering and Technology,2010
4	S. Chowdhury, S.P. Chowdhury and P. Crossley,' Microgrids and Active Distribution Networks', The Institution of Engineering and Technology
E BOOKS	
1	N. Jenkins, J.B. Ekanayake and G. Strbac,Distributed Generation, The Institution of Engineering and Technology,2010
2	S. Chowdhury, S.P. Chowdhury and P. Crossley,'Microgrids and ActiveDistribution Networks', The Institution of Engineering and Technology
MOOC	

1	Micro grid, Course era .
2	Introduction to Smart Grid, NPTEL online
3	Solar Energy: Integration of Photovoltaic Systems in Microgrids ,EDX
4	Distributed Energy - Smart Grid Resources for the Future , EDX

COURSE TITLE	ELECTRICAL SYSTEMS IN WIND ENERGY			CREDITS	3
COURSE CODE	EEB3726	COURSE CATEGORY	PE	L-T-P-S	3- 0- 0- 1
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-4				

CO	COURSE OUTCOMES	PO
1	Explain the operation of electrical generators used in wind energy systems	2,3,4,5,12
2	Carry out the steady-state analysis of electrical systems	2,3,4,5,12
3	Design and implement the suitable closed-loop controller for specific applications.	2,3,4,5,12

Prerequisites : Electrical machines and power electronics.

MODULE 1 – WIND ENERGY FUNDAMENTALS (9L)

Wind energy basics, wind speeds, wind characteristics and power production, betz coefficient, limits, Air foil terminology , blade element theory, blade design, number of blades,shapes,tipspeed, lift and drag ratio ,rotor dynamics, types of loads, balancing technique

MODULE 2 – GRID CONNECTED INDUCTION GENERATORS (9L)

Principle of operation – steady-state analysis-characteristics of GCIGs- operation of GCIGs with different power electronic configurations.

MODULE 3 – SELF EXCITED INDUCTION GENERATORS (9L)

Process of self-excitation – steady-state equivalent circuit of SEIG and its analysis - performance equations - widening the operating speed-range of SEIGs by changing the stator winding connection with suitable solid state switching schemes - power electronic controllers used in standalone systems.

MODULE 4 – DOUBLY FED INDUCTION GENERATOR (9L)

Different operating modes- steady-state equivalent circuit- performance analysis- DFIG for standalone applications- operation of DFIGs with different power electronic configurations for standalone and grid connected operation

MODULE 5 – PERMANENT MAGNET SYNCHRONOUS GENERATOR (9L)

Operation of PMSGs- steady-state analysis- performance characteristics- operation of PMSGs with different power electronic configurations for standalone and grid-connected operation.

LAB / MINI PROJECT/FIELD WORK

Modeling wind turbine Generators in MATLAB

TEXT BOOKS

1	Marcelo Godoy Simões and Felix A. Farret, 'Renewable Energy Systems: Design and Analysis with Induction Generators', CRC Press, ISBN 0849320313, 2004.
2	Ion Boldea, 'Variable speed Generators', CRC Press, ISBN 0849357152, 2006.
3	S.N. Bhadra, D.Kastha and S.Banerje, 'Wind Electrical Systems', Oxford University Press, 2005

REFERENCE BOOKS

1	Siegfried Heier, Rachel Waddington, 'Grid Integration of Wind Energy Conversion Systems, 2nd

	Edition', Wiley, June 2006, ISBN: 978-0-470-86899-7.
2	Freries LL , 'Wind Energy Conversion Systems', Prentice Hall, U.K., 1990.
E BOOKS	
1	https://books.google.co.in/books?id=vt4eAQAAIAAJ
2	https://books.google.co.in/books?isbn=111994208X
MOOC	
1	https://www.coursera.org/learn/wind-energy
2	https://www.coursera.org/lecture/wind-energy/grid-connection-of-wind-power-luqDg

COURSE TITLE	**SMART GRID TECHNOLOGIES & IOT**			**CREDITS**	**3**
COURSE CODE	**EEB3727**	**COURSE CATEGORY**	**DE**	**L-T-P-S**	**3- 0- 0- 1**
CIA	**50%**			**ESE**	**50%**
LEARNING LEVEL	**BTL-4**				

CO	**COURSE OUTCOMES**	**PO**
1	Get acquainted with different smart devices and smart meters	2,3,4,5,12
2	Describe how modern power distribution system functions	2,3,4,5,12
3	Identify suitable communication networks for Smart Grid applications	2,3,4,5,12

Prerequisites : Fundamentals of Power Distribution System, Transmission and Distribution, Power system Operation and Control, Communication Networks

MODULE 1 – INTRODUCTION TO SMART GRID (9L)

Introduction - Evolution of Electric Grid, Smart Grid Concept - Definitions and Need for Smart Grid – Functions – Opportunities – Benefits and challenges, Difference between conventional & Smart Grid, Technology Drivers

MODULE 2 – ENERGY MANAGEMENT SYSTEM (9L)

Energy Management System (EMS) - Smart substations - Substation Automation - Feeder Automation, SCADA – Remote Terminal Unit – Intelligent Electronic Devices – Protocols, Phasor Measurement Unit – Wide area monitoring protection and control, Smart integration of energy resources – Renewable, intermittent power sources – Energy Storage.

MODULE 3 – DISTRIBUTION MANAGEMENT SYSTEM (9L)

Distribution Management System (DMS) – Volt / VAR control – Fault Detection, Isolation and Service Restoration, Network Reconfiguration, Outage management System, Customer Information System, Geographical Information System, Effect of Plug in Hybrid Electric Vehicles

MODULE 4 – SMART METERS (9L)

Introduction to Smart Meters – Advanced Metering infrastructure (AMI), AMI protocols – Standards and initiatives, Demand side management and demand response programs, Demand pricing and Time of Use, Real Time Pricing, Peak Time Pricing.

MODULE 5 – COMMUNICATION NETWORKS & IOT (9L)

Elements of communication and networking – architectures, standards, PLC, Zigbee, GSM, BPL, Local Area Network (LAN) - House Area Network (HAN) - Wide Area Network (WAN) - Broadband over Power line (BPL) - IP based Protocols - Basics of Web Service and CLOUD Computing, Cyber Security for Smart Grid.

LAB / MINI PROJECT/FIELD WORK

FIELD WORK	
TEXT BOOKS	
1	Stuart Borlase 'Smart Grid: Infrastructure, Technology and Solutions', CRC Press 2012.
2	JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, 'Smart Grid: Technology and Applications', Wiley, 2012
REFERENCE BOOKS	
1	Mini S. Thomas, John D McDonald, 'Power System SCADA and Smart Grids', CRC Press, 2015
2	Kenneth C.Budka, Jayant G. Deshpande, Marina Thottan, 'Communication Networks for Smart Grids', Springer, 2014.
E BOOKS	
1	https://books.google.co.in/books?isbn=1119969093
2	https://books.google.co.in/books?isbn=135123093X
MOOC	
1	https://www.mooc-list.com/course/smart-grids-electricity-future-edx
2	https://www.mooc-list.com/course/distributed-energy-smart-grid-resources-future-edx

COURSE TITLE	**DIGITAL SIMULATION OF POWER ELECTRONIC SYSTEMS**			**CREDITS**	**3**
COURSE CODE	**EEB3728**	**COURSE CATEGORY**	**DE**	**L-T-P-S**	**3- 0- 0- 1**
CIA	**50%**			**ESE**	**50%**
LEARNING LEVEL	**BTL-4**				

CO	**COURSE OUTCOMES**	**PO**
1	To develop algorithm and software models for power electronics and drives applications	2,3,4,5,12
2	To analyze the transient and steady performance of the designed models.	2,3,4,5,12
3	To choose suitable devices or models for appropriate applications	2,3,4,5,12
4	To choose suitable devices or models based on the required applications	2,3,4,5,12
5	Will be able to model a control circuitary based on the electric machine in use.	2,3,4,5,12

Prerequisites :

MODULE 1 - ANALYSIS OF DC CIRCUITS(L9)

Review of numerical methods. Application of numerical methods to solve transients in D.C. Switched R,L, R-L, R-C and R-L-C circuits. Extension to AC circuits.

Suggested Reading: Resonance in power converters circuits- https://ieeexplore.ieee.org/xpl/mostRecentIssue.jsp?punumber=6374374

Applications: To find resonance and transients

MODULE 2 - SIMULATION OF SEMICONDUCTOR SWITCHES AND DC CIRCUITS(L9)

Modeling of diode in simulation. Diode with R, R-L, R-C and R-L-C load with ac supply. Modeling of SCR,TRIAC, IGBT and Power Transistors in simulation. Application of numerical methods to R, L, C circuits with power electronic switches. Simulation of gate/base drive circuits, simulation of snubber circuits.

Suggested Reading: Operation of all the power switches

Applications: Renewable energy systems, Speed control of Drives

MODULE 3 - ELECTRICAL MACHINE MODELLING AND SIMULATION (L9)

State space modeling and simulation of linear systems. Introduction to electrical machine modeling: induction, DC, and synchronous machines, simulation of basic electric drives, stability aspects. **Suggested Reading: The calculation and design of Electrical Apparatus** **Applications: In designing electrical machines**
MODULE 4 -SIMULATION OF RECTIFIERS AND CHOPPERS (L9)
Simulation of single phase and three phase uncontrolled and controlled (SCR) rectifiers, converters with self-commutated devices- simulation of power factor correction schemes, Simulation of converter fed dc motor drives ,Simulation of thyristor choppers with voltage, current and load commutation schemes, Simulation of chopper fed dc motor. **Suggested Reading: Calculation for passive components used for rectifiers and choppers** **Applications: Power System and Power electronics for RES**
MODULE 5 -SIMULATION OF INVERTERS AND ELECTRIC DRIVESMODULE(L9)
Simulation of single and three phase inverters with thyristors and self-commutated devices, Space vector representation, pulse-width modulation methods for voltage control, waveform control. Simulation of inverter fed induction motor drives. **Suggested Reading: Multi level inverter** **Applications: Renewable Energy Systems, Electric Drives**
LAB / MINI PROJECT/FIELD WORK
Design of Wind energy conversion system/Standalone PV system / Speed control of electric drives

	TEXT BOOKS
1	Muhammad H. Rashid **,'Power Electronics: Circuits, Devices & Applications, 4th Edition,** ©2014
2	IssaBatarseh, 'Power Electronic Circuits', John Wiley, 2004Simulink Reference Manual , Math works, USA.
3	Krishnan**,'**Electric Motor Drives: Modeling Analysis: Modeling, Analysis, and Control', Paperback – 2015
4	L. Umanand**,'**Power Electronics: Essentials & Applications ',wiley Publications, copyright 2009
	REFERENCE BOOKS
1	Steven T. Karris 'Introduction to Simulink with Engineering Applications 'Orchard Publications 2006
2	Fang Lin Luo Hong Ye Muhammad Rashid ,'Digital Power Electronics and Applications' 1st Edition,Academic Press, 2005
	E BOOKS
1	Fang Lin Luo Hong Ye Muhammad Rashid ,'Digital Power Electronics and Applications' 1st Edition,Academic Press, 2005, **eBook ISBN:** 9780080459028
	MOOC
1	https://www.coursera.org/specializations/power-electronics
2	https://www.edx.org/course/subject/electronics

COURSE TITLE	**POWER QUALITY**			**CREDITS**	**3**
COURSE CODE	**EEB3729**	**COURSE CATEGORY**	**DE**	**L-T-P-S**	**3- 0- 0- 1**
CIA	**50%**			**ESE**	**50%**
LEARNING LEVEL	**BTL-4**				
CO	**COURSE OUTCOMES**				**PO**

1	To understand different types of power quality problems with their source of generation.	2,3,4,5,12
2	To learn and characterize various power quality problems	2,3,4,5,12
3	To identify different mitigation techniques	2,3,4,5,12
4	To design active & passive filters for harmonic elimination.	2,3,4,5,12
5	To understand power quality monitoring and classification techniques	2,3,4,5,12

Prerequisites : Power Systems, Signals and Systems

MODULE 1-INTRODUCTION TO POWER QUALITY(9L)

Electric power quality phenomena - IEC and IEEE definitions - power quality disturbances - voltage fluctuations- transients- unbalance- waveform distortion- power frequency variations.

Suggested Reading: Computer Business Equipment Manufacturers Associations (CBEMA) Curve

MODULE 2-VOLTAGE SAGS AND INTERRUPTIONS(9L)

Voltage variations - Voltage sags and short interruptions – flicker-longer duration variations- sources – range and impact on sensitive circuits-standards – solutions and mitigations – equipment and techniques.

Suggested Reading: Voltage Sag Due to Induction Motor Starting

MODULE 3-TRANSIENTS (9L)

Transients – origin and classifications – capacitor switching transient – lightning-load switching – impact on users – protection – mitigation.

Suggested Reading: Introduction to computer analysis tools for transients

Applications: Protection of Transformers and Cables

MODULE 4-HARMONICS (9L)

Harmonics – sources – definitions & standards – impacts - calculation and simulation –harmonic power flow -mitigation and control techniques – filtering – passive and active.

Suggested Reading: Modelling and analysis of power quality problems by mathematical simulation tools

Applications: Harmonic / Spectrum Analyzer

MODULE 5-POWER QUALITY CONDITIONERS (9L)

Power Quality conditioners – shunt and series compensators - DSTATCOM - Dynamic voltage restorer – unified power quality conditioners - case studies.

Suggested Reading: Modelling and analysis of unified power flow controller.

Applications: Expert Systems for Power Quality Monitoring

LAB / MINI PROJECT/FIELD WORK

SVC based Reactive Power Optimization using MATLAB

TEXT BOOKS

1	Heydt, G.T., 'Electric Power Quality', Stars in a Circle Publications, Indiana, 2nd edition, 2005.
2	Bollen, M.H.J., 'Understanding Power Quality Problems: Voltage sags and interruptions', IEEE Press,New York, 2000.
3	R.S.Vedam, M.S.Sarma, "Power Quality – VAR Compensation In Power Systems," CRC Press

	2013.
REFERENCE BOOKS	
1	G.J.Wakileh, "Power Systems Harmonics – Fundamentals, Analysis And Filter Design," Springer 2007.
2	E.Aeha And M.Madrigal, "Power System Harmonics, Computer Modelling And Analysis, Wiley India, 2012.
3	Arrillaga, J, Watson, N.R., Chen, S., 'Power System Quality Assessment', Wiley, New York, 2000.
4	C. Sankaran, 'Power Quality', CRC Press, Taylor & Francis Group, 2002.
E BOOKS	
1	https://epdf.tips/power-quality.html
2	https://epdf.tips/electric-power-quality.html
3	https://epdf.tips/power-quality-in-electrical-systems.html
MOOC	
1	https://nptel.ac.in/courses/108106025/
2	https://players.brightcove.net/5229431846001/default_default/index.html?videoId=5713368134001&iframe=true&autoplay=true
3	https://players.brightcove.net/5229431846001/default_default/index.html?videoId=5713368120001&iframe=true&autoplay=true
4	https://players.brightcove.net/5229431846001/default_default/index.html?videoId=5713365925001&iframe=true&autoplay=true
5	https://players.brightcove.net/5229431846001/default_default/index.html?videoId=5713251730001&iframe=true&autoplay=true

COURSE TITLE	**ARTIFICIAL INTELLIGENCE IN ELECTRICAL DRIVES**			**CREDITS**	**3**
COURSE CODE	**EEB3730**	**COURSE CATEGORY**	**DE**	**L-T-P-S**	**3- 0- 0- 1**
CIA	**50%**			**ESE**	**50%**
LEARNING LEVEL	**BTL- 4**				

CO	**COURSE OUTCOMES**	**PO**
1.	Able to understand fundamentals of various AI based techniques	2,3,4,5,12
2.	Able to analyse various AI techniques presented for electrical machines and drives	2,3,4,5,12
3.	Able to analyse various evolution techniques	3,4,5,12

Prerequisites : power electronics

MODULE 1 – ARTIFICIAL INTELLIGENT BASED SYSTEMS (9L)

Natural language system – perception system for vision speech and touch - expert or knowledge based system – knowledge acquisition – knowledge of representation – inference strategy – expert controller.

Suggested Reading: Artificial Intelligence basics

MODULE 2 – ARTIFICIAL INTELLIGENCE(9L)

Definition, problem solving methods, searching techniques, knowledge representation, reasoning methods, predicate logic, predicate calculus, multivalue logic.

Suggested Reading: Paradigms of Artificial Intelligence Programming

Applications: Renewable Energy
MODULE 3 – FUZZY LOGIC(9L)
Concepts, fuzzy relations, membership functions, matrix representation, de-fuzzification methods **Suggested Reading: fuzzy logic with engineering application** **Applications:** Renewable Energy
MODULE 4 – ARTIFICIAL NEURAL NETWORK (9L)
Introduction, multi-layer feed forward networks, back propagation algorithms, radial basis function and recurrent networks. **Applications:** Domestic and Commercialapplications
MODULE 5 – EVOLUTIONARY TECHNIQUES(9L)
Introduction and concepts of genetic algorithms and evolutionary programming Hybrid Systems: Introduction and Algorithms for Neuro-Fuzzy, Neuro-Genetic, Genetic-Fuzzy systems. **Suggested Reading: Modern evolutionary techniques** **Applications:** Renewable Energy Conversion
LAB / MINI PROJECT/FIELD WORK
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	TEXT BOOKS
1	Rajasekaran S. and Pai G.A.V., "Neural Networks, Fuzzy Logic and Genetic Algorithm Synthesis and applications, PHI New Delhi, 2017
2	Lin C. and Lee G., "Neural Fuzzy Systems", Prentice Hall International Inc. 1996
	REFERENCE BOOKS
1	Goldberg D.E. “Genetic Algorithms in Search Optimization & Machine Learning”, Wesley Co., New York. 2000
2	Kosko B., "Neural Networks & Fuzzy Systems A dynamical systems approach to machine intelligence, Prentice Hall of India. 2008
	E BOOKS
1	https://www.kobo.com/us/en/ebooks/artificial-intelligence
2	https://courses.csail.mit.edu/6.034f/ai3/rest.pdf
	MOOC
1	https://nptel.ac.in/courses/106105077/
2	https://onlinecourses.nptel.ac.in/noc18_cs51/

COURSE TITLE	**RENEWABLE POWER GENERATION TECHNOLOGIES**			**CREDITS**	**3**
COURSE CODE	**EEB3731**	**COURSE CATEGORY**	**DE**	**L-T-P-S**	**3- 0- 0- 1**
CIA	**50%**			**ESE**	**50%**
LEARNING LEVEL	**BTL-5**				

CO	**COURSE OUTCOMES**	**PO**
1	Appraise the need and possibility of extracting solar energy and converting into electrical energy using PV cell.	2,3,4,5,12

2	Design and analyze stand-alone and grid connected PV system.	2,3,4,5,12
3	Describe the dynamics of wind turbine and electrical generator	2,3,4,5,12
4	Select and design suitable configuration of the wind energy conversion system based on application.	2,3,4,5,12
5	Suggest, design and analyze hybrid energy systems.	2,3,4,5,12

Prerequisites : Basic Electronics and Machines, Power Electronics

MODULE 1 – SOLAR ENERGY (9L)

Definition, Energy available from Sun, Solar radiation data,solar energy conversion into heat, Flat plate and Concentrating collectors, Principle of natural and forced convection. power generation.

PV Systems - Design of PV systems-Standalone system with DC and AC loads with and without battery storage-Grid connected PV systems-Maximum Power Point Tracking

MODULE 2 – WIND ENERGY (9L)

Wind energy – energy in the wind – aerodynamics - rotor types – forces developed by blades - Aerodynamic models – braking systems – tower - control and monitoring system - design considerations power curve - power speed characteristics-choice of electrical generators

MODULE 3 – WIND TURBINE GENERATOR SYSTEMS (9L)

Fixed speed induction generator-performance analysis- semi variable speed induction generator-variable speed induction generators with full and partial rated power converter topologies -isolated systems-self excited induction generator- permanent magnet alternator - performance analysis

MODULE 4 – NATURE OF GEOTHERMAL RESOURCES (9L)

Definition and classification ofresources, Utilization for electricity generation and direct heating, Wellhead power generating units. Basic features: Atmospheric exhaust and condensing, Exhaust types of conventional steam turbines. Pyrolysis of Biomass to produce solid, liquid and gaseous fuels. Biomass gasification, Constructional details of gasifier, Usage of biogas for chullas, various types of chullas for rural energy needs.

MODULE 5 – HYBRID ENERGY SYSTEMS (9L)

wind-diesel system, wind - PV system ,micro hydro-PV system ,biomass - PV-diesel system, geothermal-tidal and OTEC systems

LAB / MINI PROJECT/FIELD WORK

Mini Project: Prototype modelling of Renewable power Generation

TEXT BOOKS

1	Rai, G.D., Non-Conventional Energy Sources, Khanna Publishers 2005
2	Ashok Desai V, *Non-Conventional Energy,* Wiley Eastern Ltd, 2003
3	Mittal K.M, Non-Conventional Energy Systems, Wheeler Publishing Co. Ltd, 2003.
4	Ramesh R, Kurnar K.U, Renewable Energy Technologies,Narosa Publishing House, New Delhi, reprint 2003.

REFERENCE BOOKS

1	Chetan Singh Solanki, 'Solar Photovoltaics -Fundamentals, Technologies and Applications', PHI Learning Pvt. Ltd., New Delhi, 2011
2	Van Overstraeton and Mertens R.P., 'Physics, Technology and use of Photovoltaics', Adam Hilger, Bristol,1996.
3	John F.Walker& Jenkins. N , 'Wind energy Technology', John Wiley and sons, Chichester, UK, 1997.
4	Freries LL ,'Wind Energy Conversion Systems', Prentice Hall, U.K., 1990

E BOOKS	
1	https://books.google.co.in/books?isbn=0215521137
2	https://books.google.co.in/books?isbn=0128132175
MOOC	
1	https://www.mooc-list.com/course/wind-resources-renewable-energies-coursera
2	https://www.edx.org/course/solar-energy
3	https://www.renewableenergyworld.com/geothermal-energy/tech.html

COURSE TITLE	**ENERGY AUDITING AND MANAGEMENT**			**CREDITS**	**3**
COURSE CODE	**EEB3732**	**COURSE CATEGORY**	**DE**	**L-T-P-S**	**3- 0- 0- 1**
CIA	**50%**			**ESE**	**50%**
LEARNING LEVEL	**BTL- 4**				

CO	**COURSE OUTCOMES**	**PO**
1	Assess the energy management on various electrical equipment and metering	2,3,4,5,12
2	Adopt Conservation methods in various systems.	2,3,4,5,12
3	Learn various technically proven ways to conserve Energy and then prioritize them based on the cost benefit analysis	2,3,4,5,12
4	Illustrate the concept of lighting systems and cogeneration.	2,3,4,5,12
5	Apply Tools for energy audit and recommend measures for energy conservation	2,3,4,5,12

Prerequisites : Nil

MODULE 1 INTRODUCTION(9L)

Need for energy management - energy basics- designing and starting an energy management program – energy accounting -energy monitoring, targeting and reporting-energy audit process.

Suggested Reading: Study of energy audit report

MODULE 2 ENERGY COST AND LOAD MANAGEMENT(9L)

Important concepts in an economic analysis - Economic models-Time value of money- Utility rate structures- cost of electricity-Loss evaluation- Load management: Demand control techniques- Utility monitoring and control system-HVAC and energy management-Economic justification.

Suggested Reading: Analysis of different economic models

MODULE 3 ENERGY MANAGEMENT FOR MOTORS, SYSTEMS, AND ELECTRICAL EQUIPMENT (L9)

Energy efficient motors , factors affecting efficiency, loss distribution , constructional details , characteristics - variable speed , variable duty cycle systems, RMS hp- voltage variation-voltage unbalance- over motoring- motor energy audit. Transformer Loading/Efficiency analysis, Feeder/cable loss evaluation, case study. Reactive Power management-Capacitor

Sizing-Degree of Compensation-Capacitor losses-Location-Placement-Maintenance.

Suggested Reading: Savings calculation after implementing the above methods

MODULE 4 METERING FOR ENERGY MANAGEMENT(9L)

Relationships between parameters-Units of measure-Typical cost factors- Utility meters - Timing of meter disc for kilowatt measurement - Demand meters - Paralleling of current transformers - Instrument transformer burdens-Multitasking solid-state meters – Metering location vs. requirements

Suggested Reading: Metering techniques and practical examples

MODULE 5 LIGHTING SYSTEMS & COGENERATION(9L)

Concept of lighting systems - The task and the working space -Light sources - Ballasts –Luminaries - Lighting controls-Optimizing lighting energy - Power factor and effect of harmonics on power quality - Cost analysis techniques-Lighting and energy standards

Cogeneration: Forms of cogeneration - feasibility of cogeneration- Electrical interconnection.

Suggested Reading: Electrical Design of Buildings

TEXT BOOKS	
1	Amit K. Tyagi, Handbook on Energy Audits and Management, TERI, 2003.
2	Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, Guide Energy Management, Fifth Edition, The Fairmont Press, Inc., 2006
3	Energy management by W.R. Murphy & G. Mckay Butter worth, Heinemann publications. 2016
REFERENCE BOOKS	
1	Energy efficient electric motors by John .C. Andreas, Marcel Dekker Inc Ltd-2nd edition, 1995
2	Energy management by Paul o' Callaghan, Mc-graw Hill Book company-1st edition, 1998
E BOOKS	
1	Wayne C. Turner, " Energy Management Handbook" The Fairmont Press, 2001
2	http://www.em-ea.org/guide%20books/book-/1.3%20energy%20management%20&%20audit.pdf
MOOC	
1	https://www.coursera.org/learn/energy-101
2	https://www.coursera.org/learn/future-of-energy

COURSE TITLE	**HIGH VOLTAGE DC TRANSMISSION**			**CREDITS**	**3**
COURSE CODE	**EEB3733**	**COURSE CATEGORY**	**DE**	**L-T-P-S**	**3- 0- 0- 1**
CIA	**50%**			**ESE**	**50%**
LEARNING LEVEL	**BTL-4**				

CO	**COURSE OUTCOMES**	**PO**
1	Appraise the need of HVDC technology for bulk power transmission and choose appropriate type of HVDC link and converter.	2,3,4,5,12
2	Analyze the operation of Graetz circuit as rectifier and inverter without and with	2,3,4,5,12

	overlap.	
3	Evaluate the operation and efficacy of different controllers and analyze the different faults in HVDC systems	2,3,4,5,12
4	Discriminate and evaluate the issues related with harmonics, reactive power control and protection of HVDC system.	2,3,4,5,12
5	Recognize and appraise the recent trends in HVDC transmission systems.	2,3,4,5,12

Prerequisites : Power Electronics

MODULE 1 - INTRODUCTION 1 (9L)

Introduction to HVDC transmission, Comparison between HVAC and HVDC systems - economic, technical and reliability, limitations, Types of HVDC links - monopolar, bipolar and homopolar links, Components of HVDC transmission system.

Applications: HVDC transmission

MODULE 2 - ANALYSIS OF HVDC CONVERTERS (9L)

Analysis of HVDC Converters, Rectifier and Inverter operation of Graetz circuit without and with overlap. Output voltage waveforms and DC voltage in both rectifier and inverter operation, Equivalent circuit of HVDC link

Suggested Reading: Basic circuit operation of converter and inverter circuits

MODULE 3 - HVDC SYSTEM CONTROL 3 (9L)

Basic means of HVDC system control, desired features, power reversal, Basic controllers - constant ignition angle, constant current and constant extinction/ advance angle control, power control, high level controllers. Converter mal operations - misfire, arc through, commutation failure

Suggested Reading: Sources of converter mal operations,

MODULE 4 - POWER FLOW ANALYSIS HVDC SYSTEM H4 (9L)

Harmonics in HVDC system - Characteristic and uncharacteristic harmonics - troubles due to harmonics –harmonic filters - active and passive filters - Reactive power control of converters, Protection issues in HVDC, over voltage and over current protection, voltage and current oscillations, DC reactor design, DC Circuit breakers

Suggested Reading: Need for reactive power control

Applications: place of highly inductive loads

MODULE V - RECENT TRENDS IN HVDC TRANSMISSION (9L)

Recent trends in HVDC transmission-CCC based HVDC system, VSC based HVDC system,– Multiterminal HVDC systems and HVDC system applications in wind power generation, Inte raction between AC and DC systems

Applications: In renewable energy systems

TEXT BOOKS

1	Kamakshaiah, S and Kamaraju, V, 'HVDC Transmission', 1st Edition, Tata McGraw Hill Education (India), Newdelhi 2011
2	EdwardWilsonKimbark,"DirectCurrentTransmission",Vol.I,Wileyinterscience,New York,London,Sydney,1971
3	Padiyar,K.R.,"HVDCPowerTransmissionSystem",WileyEasternLimited,NewDelhi 1990.Firstedition

REFERENCE BOOKS

1	RakoshDasBegamudre,ExtrahighvoltageACtransmissionengineeringNewAge International(P)Ltd.,NewDelhi,1990.

2	Arrillaga,J.,HighVoltagedirectcurrenttransmission,PeterPregrinus,London,1983.
3	*Kimbark, E.W., 'Direct Current Transmission-vol.1', Wiley Inter science, New York, 1971.*
4	*Vijay K. Sood, 'HVDC and FACTS Controllers', Kluwer Academic Publishers, New York, 2004.*
E BOOKS	
1	www.engineeringbookspdf.com-padiyar
2	https://books.google.co.in/books/about/HVDC_power
MOOC	
1	https:/nptel.ac.in-courses
2	https://new.abb.com-HVDC care

COURSE TITLE	**POWER SYSTEM AUTOMATION**			**CREDITS**	**3**
COURSE CODE	**EEB3734**	**COURSE CATEGORY**	**DE**	**L-T-P-S**	**3- 0- 0- 0**
CIA	**50%**			**ESE**	**50%**
LEARNING LEVEL	**BTL-4**				

CO	**COURSE OUTCOMES**	**PO**
1	To understand the concepts of power system automation.	2,3,4,5
2	To understand the components of SCADA systems.	2,3,4,5
3	To comprehend the RTU, IED and other components of automation systems	2,3,4,5
4	To understand the transfer of signals from the field to an operator control terminal.	2,3,4,5
5	To design an interoperable powers automation system.	2,3,4,5,12

Prerequisites : Basic Knowledge of Transmission & Distribution systems and Measuring Instruments

MODULE 1-INTRODUCTION TO SCADA (9L)

Evolution of Automation systems, History of Power system Automation, Supervisory Control And Data Acquisition(SCADA) Systems, Components of SCADA systems, SCADA Applications, SCADA in power systems, SCADA basic functions, SCADA application functions in Generation, Transmission and Distribution.

Suggested Reading: SCADA based protection system

Applications: Comprehensive operational planning and control, Network security, Economic dispatch

MODULE 2-SCADA SYSTEM COMPONENTS(9L)

Advantages of SCADA in Power Systems, The Power system 'Field', Types of data &signals in the Power system, Flow of Data from the field to the SCADA Control center. Building blocks of SCADA systems, Classification of SCADA systems.

Suggested Reading: Operation and control of interconnected power system

MODULE 3-FEATURES OF RTU (9L)

Remote Terminal Unit (RTU), Evolution of RTUs, Components of RTU, Communication, Logic, Termination and Test/HMI Subsystems, Power supplies, Advanced RTU Functionalities.

Suggested Reading: Microcontroller based RTU for distribution automation system

Applications: RTU for Distribution Automation and Substation Monitoring applications

MODULE 4-COMMUNICATION SYSTEM STANDARDS FOR SCADA (9L)

Intelligent Electronic Devices (IEDs), Evolution of IEDs, IED functional block diagram, The hardware and software architecture of IED, IED Communication subsystem, IED advanced functionalities, Typical IEDs, Data Concentrators and Merging Units, SCADA Communication Systems.

MODULE 5-FEATURES OF HMI (9L)	
Master Station, Master station software and hardware configurations, Server systems in the master station, Small, medium and large master station configurations, Global Positioning Systems, Master station performance, Human Machine Interface (HMI), HMI components, Software functionalities, Situational awareness, Case studies in SCADA. **Suggested Reading:** SCADA Simulation of a distributed generation system **Applications:** Utility applications	
LAB / MINI PROJECT/FIELD WORK	
Introduction to electrical Supervisory Control & Data Acquisition (eSCADA) using ETAP	
TEXT BOOKS	
1	Mini S. Thomas, John D McDonald, Power Systems SCADA and Smart Grid, CRC Press, Taylor and Francis, 2015.
2	Electric Power Substation Engineering John D. Mc Donald CRC Press, Taylor and Francis, 2012.
REFERENCE BOOKS	
1	Control and Automation of Electrical Power Distribution systems, James North cote- Green, R Wilson, CRC Press, Taylor and Francis, 2006.
2	Electric Power Distribution, Automation, Protection and Control, James Momoh, CRC press, Taylor and Francis, 2008.
3	Biswarup Das, Power Distribution Automation, IET, 2016.
E BOOKS	
1	https://epdf.tips/queue/electric-power-distribution-automation-protection-and-control a630f51c023e86aff603a2bad92c5f6e35450.html
2	https://epdf.tips/queue/control-and-automation-of-electrical-power-distribution-systems.html
3	https://epdf.tips/queue/automation-in-electrical-power-systems.html
MOOC	
1	https://nptel.ac.in/courses/108106022/11
2	https://www.udemy.com/topic/scada/
3	https://www.tru.ca/distance/courses/wttp2311.html

COURSE TITLE	PHOTOVOLTAIC AND FUEL CELL SYSTEMS			CREDITS	3
COURSE CODE	EEB3741	COURSE CATEGORY	OE	L-T-P-S	3- 0- 0- 1
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-5				

CO	COURSE OUTCOMES	PO
1	Understand and analyse the fundamental concepts of solar PV systems	2,3,4,5,12
2	Design a solar PV power plants and its components	2,3,4,5,12
3	Understand and analyse the fundamental concepts of fuel cells	2,3,4,5,12

Prerequisites : Nil

MODULE 1 - SOLAR PV SYSTEMS (L12)
Fundamentals of solar cell, semiconductors as basis for solar cells materials and properties, P-N junction, sources of losses and prevention, estimating power and energy demand, site selection, land requirements, choice of modules, economic comparison, balance of systems, off grid systems, grid interface, Supporting structures, mounting and installation, battery storage, power condition unit, selection of cables and balance of systems, planning with software, maintenance and schedule,

Monitoring, Data Management, Performance Analysis and Financial Analysis
MODULE 2 - SOLAR PV POWER PLANTS (L12)
Array design, inverter types and characteristics, Power conditioning system: working algorithms, performance analysis; design of standalone, hybrid and grid interactive plants, commissioning of solar PV plant
MODULE 3 - FUEL CELLS (L12)
Thermodynamics of fuel cells; free energy change and cell potentials; effects of temperature and pressure on cell potential; energy conversion efficiency; factors affecting conversion efficiency; polarization losses; important types of fuel cells (hydrogen-oxygen, organic compounds-oxygen, carbon or carbon monoxide-air, nitrogen compounds-air); electrode types; electrolytes for fuel cells; applications.

TEXT BOOKS	
1	Chetan Singh Solanki, Solar Photovoltaic Technology And Systems: A Manual For Technicians, Trainers And Engineers PHI Learning Pvt.Ltd..,New Delhi 110092, 2013
2	A. K. Mukerjee, Nivedita Thakur, Photovoltaic Systems: Analysis And Design,Phi Learning Pvt.Ltd..,New Delhi 110001, 2011
3	Shripad T. Revankar, PradipMajumdar, Fuel Cells: Principles, Design, And Analysis, CRC Press, 2014
4	N.K. Bansal, Non-Conventional Energy Resources, Vikas Publishing House Pvt Ltd, New Delhi , 2014
REFERENCE BOOKS	
1	Roger A. Messenger, Amir Abtahi, Photovoltaic Systems Engineering ,4th Edition, CRC Press, 2017 (ISBN 9781498772778 - CAT# K29524)
2	Michael Boxwell , Solar Electricity Handbook - 2015 Edition: A simple, practical guide to solar energy - designing and installing solar PV systems.Green Stream Publishing, United Kingdom,2015
3	B. Viswanathan, M. AuliceScibioh, **Fuel Cells**: **Principles and Applications**, Taylor & Francis Group, 2007
E BOOKS	
1	https://courses.edx.org/c4x/DelftX/ET.3034TU/asset/solar_energy_v1.1.pdf
2	http://unesdoc.unesco.org/images/0013/001332/133249e.pdf
MOOC	
1	https://online.stanford.edu/courses/matsci256-solar-cells-fuel-cells-and-batteries-materials-energy-solution
2	https://www.mooc-list.com/course/solar-energy-photovoltaic-pv-systems-edx
3	https://www.coursera.org/lecture/energy-environment-life/fuel-cells-and-hydrogen-economy-c0VKy

COURSE TITLE	**WIND AND HYDRO ENERGY SYSTEMS**			**CREDITS**	**3**
COURSE CODE	**EEB3742**	**COURSE CATEGORY**	**OE**	**L-T-P-S**	**3- 0- 0- 1**
CIA	**50%**			**ESE**	**50%**
LEARNING LEVEL	**BTL-4**				

CO	**COURSE OUTCOMES**	**PO**
1	Understand and analyse the fundamental concepts wind energy power generation	2,3,4,5,12
2	Understand and analyse the operation and control of wind energy converter	2,3,4,5,12

3	Understand and analyse the concepts and components of hydro power generation	2,3,4,5,12

Prerequisites : Nil

MODULE 1 - WIND ENERGY (12L)

Basics :Status, Advantages and disadvantages of wind energy systems, Advantages and disadvantages, Types of wind energy converters, local Effects on wind, site selection: roughness length, wind shear, Wind Speed Variability, Obstacles to wind flow,

Working principles of wind energy: Energy content in wind, Energy Conversion at the Blade, Wind variations: Weibull distribution.

MODULE 2 - COMPONENTS , OPERATION AND CONTROL OF A WIND ENERGY CONVERTER (12L)

Components of a wind energy converter: Rotor Blades, Gearboxes, Synchronous or Asynchronous Generators, Towers, Miscellaneous components, Turbine Selection

Operation and Control of Wind Energy Converters: grid requirements, Issue of Noise and Its Control, Power Curve and Capacity Factor, Pitch control, Stall Control, Yaw Control

MODULE 3 - HYDRO POWER (12L)

Hydropower basics: Water Cycle in Nature, Classification of Hydropower Plants, Status of Hydropower Worldwide, Advantages and Disadvantages of Hydropower, Operational Terminology, Legal Requirements

Working principles: Locating a Hydropower Plant, Basics of Fluid Mechanics for hydro power, single and multiple reservoir system, cascaded power plants

Important Parts of Hydropower Station: Turbine, Electric Generator, Transformer and Power House, Structural parts: Dam and Spillway, Surge Chambers, Stilling Basins, Penstock and Spiral Casing, Tailrace, Pressure Pipes, Caverns, auxilliary parts.

Hydraulic turbines: Classification of Hydraulic Turbines, Theory of Hydro Turbines: Francis, Kaplan, Pelton turbines, efficiency and selection of turbine

TEXT BOOKS

1	Nag P K. Power Plant Engineering, 3rd Edition, Tata McGraw Hill, 2008
2	Jain P. Wind Energy Engineering. McGraw-Hill 2011
3	Wagner H. Mathur J. Introduction to Hydro energy Systems : Basics, Technology and Operation, Springer, 2011
4	Bansal RK. A textbook of fluid mechanics and hydraulic machines. Laxmi Publications, 2005, New Delhi

REFERENCE BOOKS

1	Johnson GL. Wind Energy Systems, (Electronic Edition), Prentice Hall Inc, 2006
2	Mathew S. Wind Energy: Fundamentals, Resource Analysis and Economics. Springer, 2006
3	Hussian Z. Abdullah MZ. Alimuddin Z. Basic Fluid Mechanics and Hydraulic Machines. CRC Press, 2009.

E BOOKS

1	https://nptel.ac.in/courses/108105058/24
2	https://nptel.ac.in/courses/108108078/6
3	https://www.nrel.gov/docs/fy13osti/54909.pdf
4	https://www.usbr.gov/power/edu/pamphlet.pdf
5	https://ieeexplore.ieee.org/document/6533416

MOOC

1	http://www1.rmit.edu.au/courses/045838

2	https://www.coursera.org/lecture/electric-utilities/1-7-renewables-hydroelectric-and-wind-B3YMk

COURSE TITLE	BIOMASS ENERGY SYSTEMS			CREDITS	3
COURSE CODE	EEB3743	COURSE CATEGORY	OE	L-T-P-S	3- 0- 0- 1
CIA	50%			ESE	50%
LEARNING LEVEL	BTL-4				

CO	COURSE OUTCOMES	PO
1	Understand the fundamental concepts of Biomass	1,2,3,4,5,12
2	analyse the operation and control of biomass and biogas	1,2,3,4,5,12
3	Understand and analyse the industrial and power generation aspects of biomass	1,2,3,4,5,12

Prerequisites : Nil

MODULE 1 - BIOMASS RESOURCE (L12)

Characteristics of Biomass fuel, technologies for using biomass, comparison of direct combustion with other technologies

MODULE 2 - BIOMASS GASIFIERS AND INDUSTRIAL USE OF BIOMASS (L12)

Biomass Gasifiers: Basics of Gasification and types of Gasifiers, Thermodynamic Analysis Biogas Technology, Sizing/Selection and design of Gasifiers,
Industrial use of biomass: Industrial Boilers, biomass as fuel, co-firing and co-generation,
Economic analysis, Testing and Performance Evaluation of Gasifiers, Use of biomass for liquid fuel, Biomass policy

MODULE 3 - BIOGAS (L12)

Types of biogas plants, design and performance analysis, application of biomass

TEXT BOOKS

1	Biomass Assessment Handbook - Bioenergy for a sustainable environment, Edited by Frank Rosillo-Calle, Sarah Hemstock, Peter de Groot and Jeremy Woods, Earthscan November 2006
2	Success & Visions for Bioenergy: Thermal processing of biomass for bioenergy, biofuels and bioproducts, Edited by A V Bridgwater, CPL Press September 2007.

REFERENCE BOOKS

1	Alternate Energy: Assessment & Implementation Reference Book, James J Winebrake, Springer January 2007.
2	Biofuels - Securing the Planet's Future Energy Needs, Edited by A Demirbas Springer 2009.
3	Energy Technology and Directions for the Future, John R. Fanchi, Elsevier Science February 2004

E BOOKS

1	https://nptel.ac.in/courses/108108078/7
2	https://nptel.ac.in/downloads/108108078/
3	http://www.cigr.org/documents/CIGRHandbookVol5.pdf
4	https://www.crcpress.com/Principles-of-Sustainable-Energy-Systems-Third-Edition/Kutscher-Milford-Kreith/p/book/9781498788922
5	https://link.springer.com/referencework/10.1007/978-1-4614-5820-3

MOOC

1	https://www.edx.org/course/sustainable-energy-design-a-renewable-future

COURSE TITLE	POWER SYSTEM SIMULATION LABORATORY II				2
COURSE CODE	EEB3792	COURSE CATEGORY	PC	L-T-P-S	0-0-3-0
CIA	60%		ESE	40%	
LEARNING LEVEL	BTL-4				

CO	COURSE OUTCOMES	PO MAPPING
1	To know about the computational methods for power load flow solutions	1,3,4,5,12
2	To get the knowledge about the computational methods for power load flow solutions.	1,3,4,5,12

Prerequisites: -: Basic Power Electronics

Practical **(30)**

1. Small-signal stability analysis of single machine-infinite bus system using classical machine model
2. Small-signal stability analysis of multi-machine configuration with classical machine model
3. Co-ordination of over-current and distance relays for radial line protection
4. Induction motor starting analysis
5. Load flow analysis of two-bus system with STATCOM
6. Transient analysis of two-bus system with STATCOM
7. Available Transfer Capability calculation using an existing load flow program
8. Computation of harmonic indices generated by a rectifier feeding a R-L load.

COURSE TITLE	SEMINAR				2
COURSE CODE	EEB3796	COURSE CATEGORY	PC	L-T-P-S	0-0-3-0
CIA	60%		ESE	40%	
LEARNING LEVEL	BTL-6				

CO	COURSE OUTOMES	PO
1	Able to develop simple electrical and electronic models based on the knowledge gained.	1,3,4,5,12
2	Able to propose a project and defend its advantages.	1,3,4,5,12
3	Able to implement a real time system as proposed.	1,3,4,5,12

Prerequisites: - Basic Electrical and Electronics Engineering subjects.

SEMINAR

Seminar **s**hould be taken on state of the art topic of student's own choice based on relevant specializationapproved by an Department incharge. 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.

COURSE TITLE	MINI PROJECT				2
COURSE CODE	EEB3780	COURSE CATEGORY	PC	L-T-P-S	0-0-3-0
CIA	60%		ESE	40%	
LEARNING LEVEL	BTL-6				

CO	COURSE OUTOMES	PO
1	Able to develop simple electrical and electronic models based on the knowledge gained.	1,3,4,5,12
2	Able to propose a project and defend its advantages.	1,3,4,5,12
3	Able to implement a real time system as proposed.	1,3,4,5,12

Prerequisites: - Basic Electrical and Electronics Engineering subjects.

MINI PROJECT

To carry out a mini project and simple prototype in the area of interest based on the knowledge gained in Electrical and Electronics Engineering from undergraduate and first semester

The students will carry out a project in one of the following Electrical and Electronics Engineering areas but with substantial multidisciplinary components:

- Power Electronics, Control system
- Transmission and Distribution, Power system
- Electrical Machines, Solid State Drives etc. . .

Every individual student will be assigned a faculty to guide them. There will be three major reviews which will be carried out as listed below.

Review #	Requirement	Mark Weightage	
		Internal	External
0	Area / Title selection	-	-
1	Literature review / Proposal for the Project	10%	-
2	Mathematical modelling/Circuit Design	20%	-
3	Final simulation / Hardware presentation	20%	-
End Semester Exam	Final Viva-Voce and project demonstration	-	50%