TEACHING SHEDULE & STUDY SCHEME OF M.TECH PROGRAMME {ELECTRICAL ENGINEERING POWER SYSTEM (CODE-1)}

HIMACHAL PRADESH TECHNICAL UNIVERSITY, HAMIRPUR

DETAILED SYLLABUS AND OTHER CONDITIONS FOR THE PROPOSED COURSE

M.TECH ELECTRICAL ENGINEERING
POWER SYSTEM (CODE-1)

Schedule of Teaching

Lecture	Tutorials	Total (Per week)
03	00	03

Schedule of Examination

	Time (Hrs)	Theory marks	Sessional marks	Viva	Total
All theory subjects	3	100	50		150
Seminar			50	50	100
Lab	2		25	25	50
Dissertation I			50	50	100
Dissertation II			Satisfactory/not satisfactory		

SEMESTER 1

EE1-511	Power System Operation and Control
EE1-512	Power System Analysis and Design
EE1-513	Advanced Mathematics
EE1-514	Digital Control System
EE1-515	Elective-I
EE1-516	Power System Lab-1

SEMESTER 2

EE1-521	Advance Relaying and Protection
EE1-522	Optimization Technique
EE1-523	Power System Quality Assessment
EE1-524	Facts Devices and Power Transmission
EE1-525	Elective-II
EE1-526	Power System Lab-2

SEMESTER 3

EE1-631	Power System Restructuring & Deregulation
EE1-632	Elective-III
EE1-590	Seminar
EE1-600	Dissertation I

SEMESTER 4

EE-600	Dissertation II

LIST OF ELECTIVES

ELECTIVE-1

EE1-515(A)	Power System Dynamics
EE1-515(B)	EHVAC Transmission
EE1-515(C)	Electrical Machines Modeling and Instrumentation

ELECTIVE-2

EE1-525(A)	Power System Reliability
EE1-525(B)	Advance Power Electronics
EE1-525(C)	Power system Transients

ELECTIVE-3

EE1-632(A)	Power System Planning
EE1-632(B)	Advanced Electrical Drives
EE1-632(C)	Non Conventional Energy System

Scheme of Examination										
First Semester						**Exam Schedule**		**Practical Schedule**		
Course No.	**Subjects**	**L**	**T**	**P**	**Total**	**Theory**	**Sess.**	**Pract.**	**Sess.**	**Total**
EE1-511	Power System Operation and Control	3	0	0	3	100	50	-	-	150
EE1-512	Power System Analysis and Design	3	0	0	3	100	50	-	-	150
EE1-513	Advanced Mathematics	3	0	0	3	100	50	-	-	150
EE1-514	Digital Control System	3	0	0	3	100	50	-	-	150
EE1-515	Elective-I	3	0	0	3	100	50	-	-	150
(Practical)										
EE1-516	Power System Lab-1	-	-	2	2	-	-	25	25	50
TOTAL		**15**	**0**	**2**	**17**	**500**	**250**	**25**	**25**	**800**

Scheme of Examination										
Second Semester						**Exam Schedule**		**Practical Schedule**		
Course No.	**Subjects**	**L**	**T**	**P**	**Total**	**Theory**	**Sess.**	**Pract.**	**Sess.**	**Total**
EE1-521	Advance Relaying and Protection	3	0	0	3	100	50	-	-	150
EE1-522	Optimization Technique	3	0	0	3	100	50	-	-	150
EE1-523	Power System Quality Assessment	3	0	0	3	100	50	-	-	150
EE1-524	Facts Devices and Power Transmission	3	0	0	3	100	50	-	-	150
EE1-525	Elective-II	3	0	0	3	100	50	-	-	150
(Practical)										
EE1-526	Power System Lab-2	-	-	2	2	-	-	25	25	50
TOTAL		**15**	**0**	**2**	**17**	**500**	**250**	**25**	**25**	**800**

Scheme of Examination								
Third Semester					**Exam Schedule**			
Course No.	**Subjects**	**L**	**T**	**Total**	**Theory**	**Sess.**	**viva**	**Total**
EE1-631	Power System Restructuring & Deregulation	3	0	3	100	50	-	150
EE1-632	Elective-III	3	0	3	100	50	-	150
EE1-590	Seminar	--	--	3	--	50	50	100
EE1-600	Dissertation I	--	--	3	--	50	50	100
TOTAL		**6**	**0**	**12**	**500**	**250**	**25**	**500**

Scheme of Examination					
Fourth Semester					**Exam Schedule**
Course No.	**Subjects**	**L**	**T**	**Total**	
EE1-600	Dissertation II	--	--	3	Satisfactory/not satisfactory

Course Code	**EE1-511**	**Credits: 3**	**L-3, T-0,P-0**
Name of The Course	**Power System Operation and Control**		
Lectures to be Delivered	**39(1 Hr each, for each semester)**		
Semester End Examination	**Max. Time: 3 Hrs**	**Max. Marks: 100**	**Min. Pass Marks: 40**
Continuous Assessment (Based on sessional Tests 50%, Tutorials/ Assignments 30%, Quiz/Seminar 10%, Attendance 10%)		**Max. Marks: 50**	

Instructions:

1. **For Paper Setters:** The Question paper will consist of eight questions well distributed out of the entire syllabus, are to be set. Each question will carry 20% of the total marks.
2. **For candidate**: Candidates are required to attempt any five questions. Use of non programmable calculator is allowed.

1. Characteristics of Power Generation Units:

Characteristics of steam units, variation in steam unit characteristics, cogeneration Plants, Hydro electric units.

2. Economic Dispatch of Thermal Units:

Economic Dispatch Problem, Thermal dispatching with network losses considered, Penalty factors, lambda iteration method, Gradient method, Newton's method, Dynamic Programming, Base point and participation factors. Economic dispatch vs unit commitment, constraints in unit commitment . Introduction to optimal power flow, Solution of optimal power flow by gradient method.

3. Hydro Thermal Co-ordination :

Introduction to long range and short range hydro scheduling, Types of short range scheduling problem, Scheduling energy. The short term hydro-thermal scheduling problems and its solution by Lambda-Gamma iteration method and gradient method.

4. Generation Control :

Generator ,Prime mover, Governor ,Tie line and load models ,Load frequency control, Load frequency and economic dispatch control, Automatic voltage Control, Load frequency control with generation rate constraints, Decentralized control.

5. Interchange of Power and Energy:

Economy Interchange between Inter connected utilities, Inter utility Economy Energy Evaluation , Capacity Interchange, Diversity Interchange, Energy Banking, Emergency Power Interchange, Power pools, Transmission Effects and Issues.

Books:-

1. Allen J. Wood and Brace F woollenberg, Power Generation Operation and Control, John Willey & Sons 2nd Edition .
2. D.P. Kothari and J.S. Dhillon, Power System Optimization, Prentice-Hall of India, Pvt. Ltd,. New Delhi
3. L.K .Kirchmayer, Economic Operation of Power Systems, John Willey & Sons, N.Y.
4. D.P. Kothari and I.J. Nagrath , Modern Power System Analysis ,Tata Mc Graw-Hill Publishing Company Ltd., New Delhi.

Course Code	**EE1-512**	**Credits: 3**	**L-3, T-0,P-0**
Name of The Course	**Power System Analysis and Design**		
Lectures to be Delivered	**39(1 Hr each, for each semester)**		
Semester End Examination	**Max. Time: 3 Hrs**	**Max. Marks: 100**	**Min. Pass Marks: 40**
Continuous Assessment (Based on sessional Tests 50%, Tutorials/ Assignments 30%, Quiz/Seminar 10%, Attendance 10%)		**Max. Marks: 50**	

Instructions:

1. **For Paper Setters:** The Question paper will consist of eight questions well distributed out of the entire syllabus, are to be set. Each question will carry 20% of the total marks.
2. **For candidate**: Candidates are required to attempt any five questions. Use of non programmable calculator is allowed.

1. Incidence and network matrices, formation of network matrices by singular and non-singular transformation.

2. Algorithm for formation of single phase Bus Impedance Matrix.

3. Three- phase balanced network elements, Transformation matrices, Three phase unbalanced network elements, Algorithm for formation of three phase Bus Impedance Matrix.

4. Short circuit calculations using Z-BUS for balanced and unbalanced three phase networks, symmetrical components, sequence impedances, sequence networks, Unbalanced fault analysis for three phase to ground fault, LG fault, LL Fault, LLG Fault.

5. Load flow studies using Y-BUS, Gauss-Seidel method ,Newton Raphson method, Fast Decoupled load flow method , representation of transformers, Sparsity technique.

Books:-

1. G.N. Stagg and A. H.EI- Abiad , Computer Methods in Power System Analysis, McGraw –Hill ,International Edition .
2. George L .Kusic, Computer Aided Power Systems Analysis ,Prentice Hall.
3. J. Arrillaga, C.P. Arnold and S.J. Harker, Computer Modelling of Electrical Power Systems, John Willey and Sons.
4. O.I. Elgerd Electric Energy Systems -An Introduction, Tata McGraw Hill.
5. M.A. Pai, Computer Techniques in Power Systems Analysis ,Tata McGraw Hill.
6. P.M. Anderson, Analysis of Faulted Power System, IEEE Press Book.
7. Related IEEE/IEE Publication.

Course Code	**EE1-513**	**Credits: 3**	**L-3, T-0,P-0**
Name of The Course	**Advanced Mathematics**		
Lectures to be Delivered	**39(1 Hr each, for each semester)**		
Semester End Examination	**Max. Time: 3 Hrs**	**Max. Marks: 100**	**Min. Pass Marks: 40**
Continuous Assessment (Based on sessional Tests 50%, Tutorials/ Assignments 30%, Quiz/Seminar 10%, Attendance 10%)		**Max. Marks: 50**	

Instructions:

1. **For Paper Setters:** The Question paper will consist of eight questions well distributed out of the entire syllabus, are to be set. Each question will carry 20% of the total marks.
2. **For candidate**: Candidates are required to attempt any five questions. Use of non programmable calculator is allowed.

Operational Calculus:
Laplace Transform, Inverse Laplace Transform, Convolution, z-Transform, Inverse z Transform, Convolution.

Fourier Transform :
Properties, convolution, and correlation, Fourier series and sampled waveforms, Discrete Fourier Transform (DFT), discrete convolution and correlation, Fast Fourier Transform (FFT) and its applications. FFT Convolutions and correlation, Twodimensional FFT Analysis.

Differential Equations :
Systems of Ordinary Differential Equations . Difference Equations, Concepts and applications to electric networks, Matrix representation and state variable approach.

Non-linear Ordinary Differential Equations:
Phase plane, conservation systems, structure of trajectory near-an-equilibrium point, periodic solution. limit cycles, Vander Pol equation, competing population, Volterra model.

Probability and Statistics:
Discrete Random variables; probability distributions, mean and 'standard deviation of discrete random variables, Binomial coefficients, The binomial distribution, The mean and standard deviation of a binomial random variable.

Recommended Book:

1. Kaplan, W. " Advanced Mathematics for Engineers", Addison- Wesley Publishing Company (1981).
2. Brigham, E.O. "The Fast Fourier Transform and its Applications", Prentice-Hall(1988)
3. Widrow & Stearns, " Adaptive Signal Processing" Prentice-Hall (1990)
4. Weiss, N.A and Hassett, M.J., "Introductory Statistics, Addison. Wesley Publishing Company (1993).
5. Related IEEE/IEE Publications.

Course Code	**EE1-514**	**Credits: 3**	**L-3, T-0,P-0**
Name of The Course	**Digital Control System**		
Lectures to be Delivered	**39(1 Hr each, for each semester)**		
Semester End Examination	**Max. Time: 3 Hrs**	**Max. Marks: 100**	**Min. Pass Marks: 40**
Continuous Assessment (Based on sessional Tests 50%, Tutorials/ Assignments 30%, Quiz/Seminar 10%, Attendance 10%)		**Max. Marks: 50**	

Instructions:

1. **For Paper Setters:** The Question paper will consist of eight questions well distributed out of the entire syllabus, are to be set. Each question will carry 20% of the total marks.
2. **For candidate**: Candidates are required to attempt any five questions. Use of non programmable calculator is allowed.

1. Introduction:
Configuration of the basic Digital Control Systems, types of sampling operations, Sample and Hold operations, Sampling theorem, Basic discrete time signals.

2. Analysis of Digital Control Systems :
Z-Transforms, Properties of Z-Transform, Inverse Z-Transforms, Pulse Transfer Function, Difference equations, Z-Transform method for solving the difference equations, Block diagram and signal flow graph analysis, Time response of digital control systems .
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3. Models of Digital Control Systems :
Digital temperature control System ,Digital position control system ,stepping motors and their control. Design of Digital compensator using frequency response plots.

4. Control Systems Analysis Using State Variable Methods :
State variable representation, conversion of state variable models to transfer function and vice-versa, Eigen values and eigen vectors, Solution of state equations, Concepts of controllability and observability.

5. State Variable analysis of Digital Control Systems :
State variable description of digital control systems , conversion of state variable models to pulse transfer function and vice versa , solution of state difference equations, controllability and observability.

Recommended Books :

1. M. Gopal, Digital Control and State Variable Methods, Tata Mc-Graw-Hill.
2. K.Ogata, Discrete Time Control Systems, Pearson Education, (Singapore) (Thomson Press India).
3. B.C Kuo , Digital Control Systems , Prentice Hall.
4. I.J. Nagrath & M.Gopal , Control System Engg., John Wiley & sons.
5. K.K. Aggarwal, Control System Analysis and Design, Khanna Publishers.

PTU/BOS/210/PEE/27-07-2004

Course Code	**EE1-521**	**Credits: 3**	**L-3, T-0,P-0**
Name of The Course	**Advance Relaying and Protection**		
Lectures to be Delivered	**39(1 Hr each, for each semester)**		
Semester End Examination	**Max. Time: 3 Hrs**	**Max. Marks: 100**	**Min. Pass Marks: 40**
Continuous Assessment (Based on sessional Tests 50%, Tutorials/ Assignments 30%, Quiz/Seminar 10%, Attendance 10%)		**Max. Marks: 50**	

Instructions:

1. **For Paper Setters:** The Question paper will consist of eight questions well distributed out of the entire syllabus, are to be set. Each question will carry 20% of the total marks.
2. **For candidate**: Candidates are required to attempt any five questions. Use of non programmable calculator is allowed.

Protective Relaying:
Relay terminology, Definitions, Classification, Electromechanical, static and Digital Relays, Design factors affecting performance of a protection scheme, Faults- types and evaluation, Instrument transformers for protection.

Relay Schematics and Analysis:
Over current relay- Instantaneous/Inverse Time –IDMT Characteristics, Directional Relays, Differential relays- Restraining Characteristics, Distance Relays, Types- characteristics.

Protection of Power System Equipments:
Generator, Transformer, Transmission Systems, Bus bars, Motors, Pilot wire and Carrier Current Schemes.

System grounding:

Ground faults and protection; Load shedding and frequency relaying; Out of step relaying; Re-closing and synchronizing.

Basic elements of digital protection:

Digital signal processing – Digital filtering in protection relay – digital data transmission – Numeric relay hardware – relay algorithm – distance relays – direction comparison relays – differential relays – software considerations – numeric relay testing –concept of modern coordinated control system.

Text Books/References:-

1. A T John and A K Salman-Digital protection for power systems-IEE power series-15, Peter Peregrines Ltd,UK,1997

2. C.R. Mason, The art and science of protective relaying, John Wiley &sons, 2002

3. Donald Reimert, Protective relaying for power generation systems, Taylor & Francis-CRC press 2006

4. Gerhard Ziegler-Numerical distance protection, Siemens, 2nd ed, 2006

5. A.R.Warrington, Protective Relays, Vol .1&2, Chapman and Hall, 1973

6. T S.Madhav Rao, Power system protection static relays with microprocessor applications, Tata McGraw Hill Publication, 1994

7. Helmut Ungrad , Wilibald Winkler, Andrzej Wiszniewski, Protection techniques in electrical energy systems, Marcel Dekker, Inc. 1995

8. Badri Ram , D.N. Vishwakarma, Power system protection and switch gear, Tata McGraw Hill, 2001

9. Blackburn, J. Lewis ,Protective Relaying, Principles and Applications, Marcel Dekker, Inc., 1986. Anderson, P.M, Power System Protection,. McGraw-Hill, 1999

10. Singh L.P ,Digital Protection, Protective Relaying from Electromechanical to Microprocessor, John Wiley & Sons, 1994

11. Wright, A. and Christopoulos, C, Electrical Power System Protection,. Chapman & Hall, 1993

Course Code	**EE1-522**	**Credits: 3**	**L-3, T-0,P-0**
Name of The Course	**Optimization Technique**		
Lectures to be Delivered	**39(1 Hr each, for each semester)**		
Semester End Examination	**Max. Time: 3 Hrs**	**Max. Marks: 100**	**Min. Pass Marks: 40**
Continuous Assessment (Based on sessional Tests 50%, Tutorials/ Assignments 30%, Quiz/Seminar 10%, Attendance 10%)		**Max. Marks: 50**	

Instructions:

1. **For Paper Setters:** The Question paper will consist of eight questions well distributed out of the entire syllabus, are to be set. Each question will carry 20% of the total marks.
2. **For candidate**: Candidates are required to attempt any five questions. Use of non programmable calculator is allowed.

1. Introduction to Optimization:
Statement of an optimization problem, Classification of optimization problems, Optimization techniques, Engg. applications of optimization.

2. Classical Optimization Techniques:
Single variable optimization, Multivariable optimization with no constraints, Multivariable optimization with equality constraints, Multivariable optimization with in equality constraints.

3. **Linear Programming:**
Standard form of linear programming, Graphical solution, Simplex method, two phase simplex method, Computer implementation of the simple method, Duality theory.
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4. Non-Linear Programming: One–dimensional minimization methods:
Unimodal function, Dichotomous search, Fibonacci search, Quadratic interpolation method, Cubic interpolation method .

5. Non-Linear Programming-Unconstrained Optimization Techniques:
Random search method, Steepest descent method, Conjugate gradient method, Variable metric method.

6. Non-Linear Programming - Constrained Optimization Techniques:
Interior Penalty function method, Exterior penalty function method.

Books:-

1. S.S. Rao,Optimization : Theory and applications, Wiley Eastern Ltd.
2. G.V. Reklaitis, Engg. optimization Methods & applications, Wiley.

Course Code	**EE1-523**	**Credits: 3**	**L-3, T-0,P-0**
Name of The Course	**Power System Quality Assessment**		
Lectures to be Delivered	**39 (1 Hr each, for each semester)**		
Semester End Examination	**Max. Time: 3 Hrs**	**Max. Marks: 100**	**Min. Pass Marks: 40**
Continuous Assessment (Based on sessional Tests 50%, Tutorials/ Assignments 30%, Quiz/Seminar 10%, Attendance 10%)		**Max. Marks: 50**	

Instructions:

1. For Paper Setters: The Question paper will consist of eight questions well distributed out of the entire syllabus, are to be set. Each question will carry 20% of the total marks.

2. For candidate: Candidates are required to attempt any five questions. Use of non programmable calculator is allowed.

Introduction: **P**ower quality-voltage quality-overview of power quality phenomena-classification of power quality issues-power quality measures and standards-THD-TIF-DIN-message weights-flicker factor-transient phenomena-occurrence of power quality problems-power acceptability curves-IEEE guides, EMC standards and recommended practices.

Power Assessment Under Waveform Distortion: Introduction, single phase definitions, three phase definitions, illustrative examples.

Waveform Processing Techniques: Fundamental frequency characterization, Fourier analysis, Fast Fourier Transform, Window functions, Efficiency of FFT algorithms, alternative transforms, wavelet transform, Hartely transform, Automation of disturbance recognition.

Power Quality Monitoring: Introduction, transducers, CT, PT, power quality instrumentation, Harmonic monitoring, event recording, flicker monitoring, assessment of voltage and current unbalance, examples of application

Evaluation of power system harmonic distortion: Introduction, direct harmonic analysis, incorporation of harmonic voltage sources, derivation of network harmonic impedances, solution by direct injection, Representation of individual power system components, implementation of harmonic analysis, post processing and display of results.

Harmonic Mitigation: Passive filtering, Harmonic resonance, Impedance Scan Analysis-Active Power Factor Corrected Single Phase Front End, introduction to three Phase APFC and Control Techniques,

Grounding: Grounding and wiring–introduction-NEC grounding requirements-reasons for grounding-typical grounding and wiring problems-solutions to grounding and wiring problems.

Text Books/References:

1. Electric Power Quality by G. T. Heydt, Stars in a Circle Publishers, 1994.
2. Understanding Power Quality Problems by Math H. Bollen.
3. J. Arrillaga, Power System Quality Assessment., John Wiley, 2000.
4. J. Arrillaga, B. C. Smith, N. R. Watson & A. R. Wood, Power System Harmonic Analysis, John Wiley, 1997.
5. Surya Santoso, H. Wayne Beaty, Roger C. Dugan, Mark F. McGranaghan, Electrical Power System Quality, McGraw Hills, 2002.

Course Code	**EE1-524**	**Credits: 3**	**L-3, T-0,P-0**
Name of The Course	**Facts Devices and Power Transmission**		
Lectures to be Delivered	**39(1 Hr each, for each semester)**		
Semester End Examination	**Max. Time: 3 Hrs**	**Max. Marks: 100**	**Min. Pass Marks: 40**
Continuous Assessment (Based on sessional Tests 50%, Tutorials/ Assignments 30%, Quiz/Seminar 10%, Attendance 10%)		**Max. Marks: 50**	

Instructions:

1. **For Paper Setters:** The Question paper will consist of eight questions well distributed out of the entire syllabus, are to be set. Each question will carry 20% of the total marks.
2. **For candidate**: Candidates are required to attempt any five questions. Use of non programmable calculator is allowed.

FACTS concepts and General system considerations:
Introduction to power semiconductor devices, Diode, GTO, MOSFET, IGBT, MOS Controlled Thyristor**,** Transmission interconnection, power flow in ac system, power flow and dynamic stability considerations, Basic of FACTS controllers, shunt, series, combined and other controllers, FACTS technology, HVDC or FACTS

Voltage Source Converters:
Basic concepts, single phase full wave bridge converter operation, three phase full wave bridge converter, sequence of valve conduction process in each phase leg, transformer connections for 12 pulse operation, three level voltage sourced converter, PWM converter.

Self and Line Commutated Current Sourced Converters:
Basic concepts, three phase full wave diode rectifier, thyristor based converter, Rectifier and inverter operation valve voltage and commutation failure, Current sourced versus voltage sourced converters.

Harmonics and Filters:
Harmonics on ac side and dc side of converter, characteristics and uncharacteristic harmonics, troubles caused by harmonics, harmonic filters.

FACTS Devices: Introduction: objectives of shunt compensation, methods of controllable Var Generation, static Var Compensators, SVC and STATCOM, Static series compensators, TSSC, TCSC and SSC.

Text Books/Reference:-

1. Understanding FACTS concepts and Technology of Flexible AC Transmission system", N.G. Hingorni and L. Ayugyi, standard Publication New Delhi (2001).
2. HVDC power transmission, K.R.Padiar.
3. High voltage direct current Transmission by J. Arrillaga.
4. Direct Current transmission, E.W.Kimbark.

Course Code	**EE1-631**	**Credits: 3**	**L-3, T-0,P-0**
Name of The Course	**Power System Restructuring & Deregulation**		
Lectures to be Delivered	**39(1 Hr each, for each semester)**		
Semester End Examination	**Max. Time: 3 Hrs**	**Max. Marks: 100**	**Min. Pass Marks: 40**
Continuous Assessment (Based on sessional Tests 50%, Tutorials/ Assignments 30%, Quiz/Seminar 10%, Attendance 10%)		**Max. Marks: 50**	

Instructions:

1. For Paper Setters: The Question paper will consist of eight questions well distributed out of the entire syllabus, are to be set. Each question will carry 20% of the total marks.

2. For candidate: Candidates are required to attempt any five questions. Use of non programmable calculator is allowed.

Introduction:

Basic concept and definitions, privatization, restructuring, transmission open access, wheeling, deregulation, components of deregulated system, advantages of competitive system.

Power System Restructuring:

An overview of the restructured power system, Difference between integrated power system and restructured power system. Explanation with suitable practical examples.

Deregulation of Power Sector:

Separation of ownership and operation, Deregulated models, pool model, pool and bilateral trades model, multilateral trade model. Competitive electricity market: Independent System Operator activities in pool market, Wholesale electricity market characteristics, central auction, single auction power pool, double auction power pool, market clearing and pricing, Market Power and its Mitigation Techniques, Bilateral trading, Ancillary services, Transmission Pricing.

Open Access Same Time Information System (OASIS):

Introduction, structure, functionality, implementation, posting of information, uses.

Congestion Management:

Congestion management in normal operation, explanation with suitable example, total transfer capability (TTC), Available transfer capability (ATC), Transmission Reliability Margin (TRM), Capacity Benefit Margin (CBM), Existing Transmission Commitments (ETC).

Different Experiences in deregulation:

U.S.A, Canada, U.K, Japan, Switzerland, Australia, Sweden, Germany and Indian power system.

Books/ References:

1. "Power System Restructuring and Deregulation" Edited by Loi Lei Lai, John Wiley & Sons Ltd.

2. "Understanding Electric Utilities and Deregulation", Lorrin Philipson and H. Lee Willis, Marcel Dekker Inc, New York, CRC Press, 2005.

3. Power System Restructuring Engineering & Economics by Marija llic, Francisco Galiana and Lestor Fink, Kulwer Academic Publisher, USA-2000.

Course Code	**EE1-515(A)**	**Credits: 3**	**L-3, T-0,P-0**
Name of The Course	**Power System Dynamics**		
Lectures to be Delivered	**39(1 Hr each, for each semester)**		
Semester End Examination	**Max. Time: 3 Hrs**	**Max. Marks: 100**	**Min. Pass Marks: 40**
Continuous Assessment (Based on sessional Tests 50%, Tutorials/ Assignments 30%, Quiz/Seminar 10%, Attendance 10%)		**Max. Marks: 50**	

Instructions:

1. **For Paper Setters:** The Question paper will consist of eight questions well distributed out of the entire syllabus, are to be set. Each question will carry 20% of the total marks.
2. **For candidate**: Candidates are required to attempt any five questions. Use of non programmable calculator is allowed.

1. Introduction:
Classification of electromechanical transients, Steady state, transient and resultant stabilities, basis for representation of power systems as two machines and multimachine system.

2. Steady state and transient characteristics of a two machine systems:
a) Phasor diagrams and expressions for active and reactive power in terms of voltages Eq., Eq', and Vg for salient and non salient pole machines (excluding resistance). Derivation of power expressions including resistance.
b) Characteristics of sending end generator at synchronous sPEd.
c) Characteristics of the generator at asynchronous sPEd.

3. Steady State and transient characteristics of multi-machine system:
a) Characteristics of linear system with machines running at asynchronous sPEd.
b) Characteristics of linear system with machine running at synchronous sPEd.
c) Characteristics of non-linear elements.

4. Steady state stability of two machine systems:
a) Unregulated case: Simple analysis of steady state stability, effect of damping and turbine regulation on small oscillations, effect of induced currents in field winding.

b) Regulated case: Characteristics and types of excitation systems, forced excitation system. transfer function of automatically regulated synchronous machine, stability analysis with forced excitation regulator, influence of automatically regulated machine on the small oscillations in the systems.

5. Steady state stability of multi-machine systems.

6. Transient stability of two machine systems: Equal area criterion, swing equation, approximate solution of swing equation, effect of excitation and turbine control.

7. Transient Stability of multi-machine systems: transient stability of interconnected power systems, introduction to asynchronous operation of synchronous machines.

Recommended Books:
1. Transient phenomenon to power systems by Venikov V.A.
2. Introduction to Electrical Energy System by O. I Elgerd.
3. Power System Stability Vol. I, II. III by Kimbark.
4. Power System Stability Vol- I. II by Crary.
5. Power System Analysis by Stevenson.

Course Code	**EE1-515(B)**	**Credits: 3**	**L-3, T-0,P-0**
Name of The Course	**EHVAC Transmission**		
Lectures to be Delivered	**39(1 Hr each, for each semester)**		
Semester End Examination	**Max. Time: 3 Hrs**	**Max. Marks: 100**	**Min. Pass Marks: 40**
Continuous Assessment (Based on sessional Tests 50%, Tutorials/ Assignments 30%, Quiz/Seminar 10%, Attendance 10%)		**Max. Marks: 50**	

Instructions:

1. **For Paper Setters:** The Question paper will consist of eight questions well distributed out of the entire syllabus, are to be set. Each question will carry 20% of the total marks.
2. **For candidate**: Candidates are required to attempt any five questions. Use of non programmable calculator is allowed.

Introduction to EHV AC Transmission,
Tower Configurations, types of self supporting Lattice towers, Flexible and Semi Flexible towers. Thermal Rating of Lines, Temperature rise of conductors and current carrying capacity of lines and cables, properties of bundled conductor, Average value of line parameters, power handling capacity and line loss, selection of cable for EHV AC transmission, Electrical characteristics and cable insulating materials. Types of circuit breakers for EHV AC system.

Voltage gradient of conductors:
field of line charges and their properties , surface voltage gradient on conductors, maximum surface voltage gradient . Corona Effects, Corona formulas based on voltages and voltage gradients, Corona currents, Power loss, Audible Noise and Radio interference , Limits of audible noise, AN measurements ,day night equivalent noise level.

Electrostatic field of EHV lines:
Capacitance of long objects under transmission lines, electrostatic field of 3 phase single circuit and double circuit AC lines, Biological effects of electrostatic fields.

Lightning and Lightning Protection :
Over voltage factors, type of surge arresters, rating and classification of surge arresters based on applications , insulation withstand characteristics of long air gaps. Design of EHV Lines based on Steady-State limits, transients, voltage stability, series and shunt compensation, reactive power control apparatus.

Recommended Books:
1. R.D. Begamudre , EHV AC Transmission , Wiley Eastern Ltd., 2nd edition .
2. Transmission Line Reference Book: 345 KV and above EPRI, Palo Alto USA.
3. Electrical Transmission and Distribution Reference Book , Oxford book Company, Calcutta.
4. S. Rao ,EHV –AC and HV DC Transmission Engineering Practice, Khanna Publishers.
5. Related IEEE/IEE Publications.

Electrical Machines Modeling and Instrumentation EE1-515(C)

Course Code	**EE1-515(C)**	**Credits: 3**	**L-3, T-0,P-0**
Name of The Course	**Electrical Machines Modeling and Instrumentation**		
Lectures to be Delivered	**39(1 Hr each, for each semester)**		
Semester End Examination	**Max. Time: 3 Hrs**	**Max. Marks: 100**	**Min. Pass Marks: 40**
Continuous Assessment (Based on sessional Tests 50%, Tutorials/ Assignments 30%, Quiz/Seminar 10%, Attendance 10%)		**Max. Marks: 50**	

Instructions:

1. **For Paper Setters:** The Question paper will consist of eight questions well distributed out of the entire syllabus, are to be set. Each question will carry 20% of the total marks.
2. **For candidate**: Candidates are required to attempt any five questions. Use of non programmable calculator is allowed.

1. <u>Polyphase Synchronous Machines:</u>

a. Mathematical Modelling: Basic Synchronous machine parameters, Voltage, Flux linkage and inductance relations, Park's transformation - its physical concept, equations of performance.

b. Balanced Steady State Analysis: Phasor equations and phasor diagrams, Power-angle characteristics, cylindrical rotor and Salient pole machines, Short circuit ratio.

c. Transient Analysis: Three phase short circuit Armature and field transients, Transient torque, Sudden reactive loading and Unloading. Transient Analysis -a qualitative approach, Reactances and time , constants from equivalent circuit .Measurement of Reactances, Transient Power angle characteristics.

d. Synchronous - machine Dynamics: The basic electromechanical equation, Linearized Analysis, Large Angular/oscillation, Non-linear analysis.

2. <u>Transformers:</u>

a. Multi-Circuit Transformers: General theory, Equivalent circuits, Three winding transformer as a multi-circuit transformers, Determination of parameters.

b. Excitation phenomena in Transformers: Harmonics in Single – phase transformers, Harmonics in three-phase transformers, Disadvantages of harmonics, Suppression of harmonics.

c. Transformer Transients: Inrush current phenomena, Qualitative approach, Analytical approach, Inrush current in 3-phase transformers.

d. Unbalanced Operation of three-phase Transformers: Single phase load on three-phase transformers, Single - Phasing in 3-phase transformers, Effect of using tertiary winding.

Recommended Text Book:
Generalized theory of Electrical Machines by Dr. P.S. Bimbhra (Khanna Publishers.)

Reference Books:
1. Generalized theory of electrical Machines by B. Edkins.
2. Synchronous machines by Concordia.
3. Power System Stability Vol. III by E.W, Kimbark.
4. Electrical Machinery by Fitzegerald, Kingsley.
5. Electrical Machines by A. Draper.

Course Code	**EE1-525(A)**	**Credits: 3**	**L-3, T-0,P-0**
Name of The Course	**Power System Reliability**		
Lectures to be Delivered	**39(1 Hr each, for each semester)**		
Semester End Examination	**Max. Time: 3 Hrs**	**Max. Marks: 100**	**Min. Pass Marks: 40**
Continuous Assessment (Based on sessional Tests 50%, Tutorials/ Assignments 30%, Quiz/Seminar 10%, Attendance 10%)		**Max. Marks: 50**	

Instructions:

1. **For Paper Setters:** The Question paper will consist of eight questions well distributed out of the entire syllabus, are to be set. Each question will carry 20% of the total marks.
2. **For candidate**: Candidates are required to attempt any five questions. Use of non programmable calculator is allowed.

1. Basic Reliability Concepts: The General reliability function, Hazard rate, MTTF, Markov processes.

2. **Static Generating Capacity Reliability Evaluation:** Capacity outage probability tables, loss of load probability method, Frequency and duration approach.

3. Spinning Generation Capacity Reliability Evaluation: Spinning capacity evaluation, Load forecast uncertainty, Derated capacity levels.

4. Transmission System Reliability Evaluation: Average interruption rate method, Frequency and duration method, Stormy and normal weather effects, The Markov process approach.

5. Composite System Reliability Evaluation: Conditional probability approach, two –plant single load system.

Books: –

1. R. Billinton & R.N. Allan, "Reliability evaluation of Engineering Systems, Concepts and techniques " Pittnan Books 1983.
2. R. Billinton & R.N. Allan, "Reliability evaluation of Power Systems, Pittman Books 1984.
3. C. Singh & R. Billinton, System Reliability Modelling and Evaluations, Hutchison of London 1977.
4. J. Endrenyi, Reliability Modelling in Electric Power Systems, John Wiley & Sons, NY. 1979.

Course Code	**EE1-525(B)**	**Credits: 3**	**L-3, T-0,P-0**
Name of The Course	**Advance Power Electronics**		
Lectures to be Delivered	**39(1 Hr each, for each semester)**		
Semester End Examination	**Max. Time: 3 Hrs**	**Max. Marks: 100**	**Min. Pass Marks: 40**
Continuous Assessment (Based on sessional Tests 50%, Tutorials/ Assignments 30%, Quiz/Seminar 10%, Attendance 10%)		**Max. Marks: 50**	

Instructions:

1. **For Paper Setters:** The Question paper will consist of eight questions well distributed out of the entire syllabus, are to be set. Each question will carry 20% of the total marks.
2. **For candidate**: Candidates are required to attempt any five questions. Use of non programmable calculator is allowed.

I. Power Semiconductor Diodes: Diode V -I Characteristics, Reverse Recovery Characteristics, Power Diodes Types, Forward and Reverse Recovery Time. Series & Parallel Connected Diodes.

2. **Thyristor:** V -1 Characteristics, Turn ON & Turn OFF Characteristics, di/dt and dv/dt protection, Series and Parallel Operation of Thyristors, Thyristor firing circuits, UJT and PUJT, Thyristor commutation Techniques.

3. Power Transistors: Bipolar Junction Transistors, their steady State & Switching Characteristics, Power MOSFET'S and their steady state & switching characteristics, Gate drive SIT's & IGBTS's, Series & Parallel Operation, di/dt and dv/dt limitations,

4. Controlled Rectifiers: Single Phase & Three Phase full Converters with R-L load, Single phase &:three phase dual converters, Power factor improvement technique.

5.A.C. Voltage Controllers: Principle of phase control, Single phase and three phase full controllers, Cycloconvertor, A.C. voltage Controllers with PWM Control, Effects of source & Load Inductances.

6. D.C Choppers: Chopper Classification, Thyristor Chopper Circuits, Chopper Circuit Design.

7. PWM Inverters: Principle of Operation, Performance parameters, single phase bridge invertors and their voltage Control, Harmonic Reduction, Inverter Circuit Design.

Recommended Books:-

I. M.H. Rashid, Power Electronics Circuits Devices application, PHI.1994
2. P. C. Sen., Power Electronics TMH 1987.
3. P S . Bimbhra., Power Electronics, Khanna Publishers 1993.
4. Cyril W Lander, Power Electronics, MHL, 1993.
5. M.D Singh & K.B. Khanchandani, Power Electronics, TMH.1998.
6. Related IEEE/IEE Publication

Course Code	**EE1-525(C)**	**Credits: 3**	**L-3, T-0,P-0**
Name of The Course	**Power system Transients**		
Lectures to be Delivered	**39(1 Hr each, for each semester)**		
Semester End Examination	**Max. Time: 3 Hrs**	**Max. Marks: 100**	**Min. Pass Marks: 40**
Continuous Assessment (Based on sessional Tests 50%, Tutorials/ Assignments 30%, Quiz/Seminar 10%, Attendance 10%)		**Max. Marks: 50**	

Instructions:

1. **For Paper Setters:** The Question paper will consist of eight questions well distributed out of the entire syllabus, are to be set. Each question will carry 20% of the total marks.
2. **For candidate**: Candidates are required to attempt any five questions. Use of non programmable calculator is allowed.

1. **Origin and nature of power system Transients**, Traveling waves on transmission system. The line equation. The shape attenuation and distortion of waves, reflection of traveling waves, Successive ref1ections, Traveling waves on multi-conductor systems. Transition points on multi conductor circuits.

2. **Lightening:** Charge formation. Mechanism of lightening stroke, Mathematical model of lightening stroke.

3. **Theory or Ground Wires:** Direct Stroke to a tower, Effect of reflection up and down the tower, the counterpoise.

4**. Switching Surges:** Normal frequency effects, High charging currents, cancellation waves, Recovery voltage, Restricting phenomena.

5. Protection of transmission systems against surge.

6. High frequency oscillations and terminal transients of transformer.

7. Insulation co-ordination.

References Books:

1. L.V. Bewley, Traveling waves on transmission systems, power Publication lnc New York, 1963.
2. R. Rudenterg, Electric Stroke waves in Power Systems, Harvard University Press, Cambridge, Massachusetts, 1968.
3. Allan Green Wood, Electrical Transients in Power Systems, Wiley lnterscience, 1971.
4. EPRI, Transmission Line reference Book 345 KV and above, 1984.
5. Surge Protection in Power Systems. IEEE Publication, 79 EHD 144-46 PWR.
6. Regaller K. Surges in High Voltage Networks, Plenum Press, 1980.
7. Related IEEE/IEE Publications.

Course Code	**EE1-632(A)**	**Credits: 3**	**L-3, T-0,P-0**
Name of The Course	**Power System Planning**		
Lectures to be Delivered	**39(1 Hr each, for each semester)**		
Semester End Examination	**Max. Time: 3 Hrs**	**Max. Marks: 100**	**Min. Pass Marks: 40**
Continuous Assessment (Based on sessional Tests 50%, Tutorials/ Assignments 30%, Quiz/Seminar 10%, Attendance 10%)		**Max. Marks: 50**	

Instructions:

1. **For Paper Setters:** The Question paper will consist of eight questions well distributed out of the entire syllabus, are to be set. Each question will carry 20% of the total marks.
2. **For candidate**: Candidates are required to attempt any five questions. Use of non programmable calculator is allowed.

1. **Introduction:** Review of load forecasting, the electric utility industry, growth characteristics generation, transmission and distribution systems.

2. **Generation System Planning:** Optimal scheduling of generation units, Optimal power flow, Optimal scheduling of hydro-thermal power system, Unit commitment, Reliability based generation system, Expansion planning, Unit maintenance schedule, Unit effective load carrying capability, Generation system cost analysis.

3. **Transmission System Planning:** Automatic transmission system expansion planning, Automatic transmission planning using interactive graphics.

4. **Distribution System Planning and Automation:** Load characteristics, Design of sub transmission lines and distribution, substations, Design considerations of' primary and secondary distribution systems, Voltage drop and power loss calculations, Distribution system, voltage regulation, application of capacitors to distribution systems.

Recommended Books:

1. R.L. Sul1ivan, Power System Planning, McGraw Hill International Book Co., 1977.
2. A.S. Pabla, Electrical Power System Planning , Macmillan 1998.
3. Related IEEE/IEE Publications

Course Code	**EE1-632(B)**	**Credits: 3**	**L-3, T-0,P-0**
Name of The Course	**Advanced Electrical Drives**		
Lectures to be Delivered	**39(1 Hr each, for each semester)**		
Semester End Examination	**Max. Time: 3 Hrs**	**Max. Marks: 100**	**Min. Pass Marks: 40**
Continuous Assessment (Based on sessional Tests 50%, Tutorials/ Assignments 30%, Quiz/Seminar 10%, Attendance 10%)		**Max. Marks: 50**	

Instructions:

1. **For Paper Setters:** The Question paper will consist of eight questions well distributed out of the entire syllabus, are to be set. Each question will carry 20% of the total marks.
2. **For candidate**: Candidates are required to attempt any five questions. Use of non programmable calculator is allowed.

1. **Introduction:** Concept and classifications, Selection.

2. **Dynamics of Electrical Drives:** Loads, Quadrantal diagram of sPEd-torque Characteristics, Load torque variation, Dynamics of motor load combination, Steady state and transient Stability of electric drive.

3. **Review of motor Characteristics:** Modified sPEd-torque characteristics of d.c. shunt and series motors, Modified sPEd-torque characteristics of three phase induction motor, Variation of applied voltage, Variation of Supply frequency.

4. **Starting:** Review of motor starting methods, Acceleration time, Energy relation. Dynamics of Braking, Thyristor Controlled Electrical Drives.

6. **D.C. Motor Drives:** Controlled rectifier d.c. drives, Chopper-fed d.c. motor drives, Separately excited and series motors, Steady State Performance.

7. **Induction Motor Drives:** Variable frequency control, slip power control, Chopper controlled resistance in the rotor Circuit.

8. **Industrial Applications**: Steel mills, Hot and Cold rolling mills, Paper Mills, Cement Mills.

Recommended Books:

1. A first Course on Electrical Drives by S,K, Pillai, Wiley Eastern.
2. Thyristor control of Electric Drives by V, Subrahmanyam, Tata McGraw-Hill.
3. Thyristor d.c. drives by S.K. Sen.
4. Electric Machines and Drives by Fransua.
5. Control system in Industry by Siskind, McGraw-Hill.
6. Related IFEE/IEE Publications

Course Code	**EE1-632(C)**	**Credits: 3**	**L-3, T-0,P-0**
Name of The Course	**Non Conventional Energy System**		
Lectures to be Delivered	**39(1 Hr each, for each semester)**		
Semester End Examination	**Max. Time: 3 Hrs**	**Max. Marks: 100**	**Min. Pass Marks: 40**
Continuous Assessment (Based on sessional Tests 50%, Tutorials/ Assignments 30%, Quiz/Seminar 10%, Attendance 10%)		**Max. Marks: 50**	

Instructions:

1. **For Paper Setters:** The Question paper will consist of eight questions well distributed out of the entire syllabus, are to be set. Each question will carry 20% of the total marks.
2. **For candidate**: Candidates are required to attempt any five questions. Use of non programmable calculator is allowed.

1. Introduction to Energy Sources: World Energy Futures, Conventional Energy Sources, Non Conventional Energy Sources, Prospects of Renewable Energy Sources.

2. Solar Energy: -

a) Introduction to Solar Radiation and its measurement, Introduction to Solar Energy Collectors and Storage.

b) Applications of Solar Energy: Solar Thermal Electric Conversion, Thermal Electric Conversion Systems, Solar Electric power Generation, Solar Photo- Voltaics, Solar Cell Principle, Semiconductor Junctions, Conversion efficiency and power output, Basic Photo Voltaic System for Power Generation.

3. Wind Energy:

a) Introduction to wind energy Conversion, the nature of the wind, Power in the wind.

b) Wind Energy Conversion: Wind data and energy estimation, Site Selection Considerations, Basic Components of a Wind Energy Conversion System, Classification of WEC Systems, Schemes for Electric Generation using Synchronous Generator and Induction Generator, Wind energy Storage.

4. Direct Energy Conversion Processes:

a) Magneto Hydro Dynamic Power Generation: Principles of MHD power generation, Open Cycle Systems, Closed Cycle Systems, Voltage and power output, Materials for MHD generators.

b) Thermo-Electric Generation: Basic principles of thermo-electric powergeneration, Seebeck, Peltier, Thomson effects, Thermo-Electric power generator, Analysis, materials.

c) Thermionic Generation: Thermionic emission and work function, Basicthermionic generation.

d) Fuel Cells 2, 2 *H O* **C**ell, Classification of fuel Cells, Types, Advantages, Electrodes, Polarization.

e) Thermo Nuclear Fusion Energy: The basic Nuclear Function and Reactions Plasma Confinement, Thermo Nuclear function Reactions.

5. Energy From Biomass:

a) Introduction: Biomass conversion technologies, photosynthesis, Bio-gas generation, types of bio-gas plants.

b) Biomass as a Source of Energy: Method for obtaining energy from Bio-mass, Biological Conversion of Solar Energy.

Reference Books:

1. Non-Conventional Sources of Energy by :G.D. Rai, Khanna Publishers.
2. Bio Energy by David Boyles, Elis Horwood Ltd.,
3. Renewable energy sources and conversion technology by N.K. Bansal, M. Kleemann, M. Heliss, Tata McGraw Hill 1990.
4. Direct Energy Conversion by R. A. Coombie, Pitman.
5. Bio Energy Spectrum, Bio Energy and Wasteland Development Organization by O.P Vimal and P.D. Tyagi.
6. Related IEEE/IEE Publications.

POWER SYSTEM LAB-1
EE1-516

Hours per week- 2

LIST OF EXPERIMENTS:-

1. Develop a program for solving
    a. Unit commitment problem
    b. Thermal dispatch problem
    c. Hydro thermal co-ordination problem
2. Simulate single area and two area system using any application software.
3. Develop a program for Y – bus formation by two dimensional matrixes.
4. Develop a program for load flow by Newton Raphson method.
5. Develop a program for load flow by fast decoupled method.
6. Develop a program for Z- bus formation
7. Measurement of sequence reactance of 3-phase alternator and 3- phase transformer.
8. Study of characteristics of long transmission lines using lab models.

POWER SYSTEM LAB-2
EE1-526

Hours per week- 2

LIST OF EXPERIMENTS:-

1. Develop a program for WLS linear state estimation.
2. Develop a program for WLS Non- Linear state estimation.
3. Develop a program for DC load flow based WLS Sequential State Estimation.
4. Develop a program for security constrained OPF using soft computing technique and simulate using application software.
5. Simulate various facts devices using application software.
6. Power quality analysis of various loads and UPS system using Power Quality Analyzer.
7. Insulation testing of UG cables.
8. Testing of transformer oil.
9. Model of closed loop buck converter and simulate using any application software.