Panjab University

Scheme and Syllabus of

Master of Engineering (Electrical Engg.)
(Power Systems)
First-Fourth Semester Examinations,
2019-20

Scheme of Evaluation (Semester-wise)

M.E. (Electrical Engineering)
(POWER SYSTEMS)
(2019-20)

1. Duration of the Programme

The normal duration of M.Tech./ME programmes including Thesis will be two academic years(four semesters). The maximum period of completion of the programme including Thesis shallbe three academic years (six semesters).

2. Number of Papers allowed in a Semester

All students will be required to qualify twelve theory papers and two practical papers duringthe course. No student will be allowed to qualify more than five theory and one practicalpaper at the end of first semester and not more than ten theory and two practical papers(including the papers passed in the first semester), at the end of second semester or first year.Two papers will be offered in the 3rd semester.

3. Conditions for Appearing in End-Semester Examination

Every student has to appear in two periodic tests as decided by the department and must qualifythe same. There will be only one make-up test for those students who are unable to appear inone or both mid-semester tests due to genuine reasons to the satisfaction of Coordinator.Students, whose performance in the class-tests & sessionals is not satisfactory, are liable tobe detained by the Director from appearing at the University Examinations. The detailedrules of the University Examinations are available inPanjab University, Chandigarh and allstudents are advised to get the latest copy for guidance and further information.

4. Examination and Result

- Minimum marks to pass examination: 50% in the sessional in each subject and 40% in eachtheory paper. Both the theory and sessional marks will be considered independent of each other. Aggregate pass percentage will be 50%
- Weightage in each subject: 50 marks : Sessionalexaminations and 50 marks : University Theory Examination
- The students who obtain, in first attempt, 75% or more of the aggregate marks in both theoryand sessionals and also if the thesis has been adjudged to merit distinction are awardedFirst Division with Distinction.
- The students who obtain 60% or less than 75% of the aggregate marks in all theory papers and the sessionals are awarded First Division.

- The students who obtain less than 60% of the aggregate marks in all the theory papers and the sessionals\s but not less than 40% in each theory paper and 50% in the sessionals willbe awarded Second Division.

5. Preliminary Thesis/Thesis

Four neatly typed or printed copies of Thesis properly bound, shall be submitted to PanjabUniversity through Guide.The suggested guidelines for awarding grade to the candidate for the thesis are as follows:

S. No.	Grade	Expected Publications from Thesis Work
1.	**A+**	**Publication in SCI/SCIE indexed Journal**
2.	**A**	**Publication in Scopus/ESCI indexed Journal / Conference**
3.	**B+**	**Paper presented in International / National Conference / Other Journals**

MASTER OF ENGINEERING (ELECTRICAL ENGINEERING)

POWER SYSTEMS SPECIALIZATION

Scheme for Examination

FIRST SEMESTER

S. No.	Subject Code	Subject Name	L-T-P	Contact hrs/week	Credits	Marks		
						Theory		Practical*
						Internal Assessment	University Exam	
1	EE-8101	Advanced Power System Analysis	4-0-0	4	4	50	50	----
2	EE-8102	Power System Operation And Control	3-0-2	5	3+1	50	50	50
3	EE-8103	Optimization Techniques	4-0-0	4	4	50	50	----
4	EE-8104	Digital Control Systems	4-0-0	4	4	50	50	----
5	EE-8105	Power Quality	4-0-0	4	4	50	50	----

* Practical marks are for continuous and end semester evaluation

Total Marks: 550 **Total Credits: 20**

SECOND SEMESTER

S. No.	Subject Code	Subject Name	L-T-P	Contact hrs/week	Credits	Marks		
						Theory		Practical*
						Internal Assessment	University Exam	
1	EE-8201	Power Systems Dynamics and Stability	4-0-0	4	4	50	50	----
2	EE-8202	EHVAC Transmission	4-0-0	4	4	50	50	----
3	EE-8203	Advanced Neural Networks and Fuzzy Logic	3-0-2	5	3+1	50	50	50
4		Elective-I	4-0-0	4	4	50	50	----
5		Elective-II	4-0-0	4	4	50	50	----
6	EE-8252	Research Seminar	0-0-3	3	2	----	----	50

* Practical marks are for continuous and end semester evaluation

Total Marks: 600 **Total Credits: 22**

Elective I
EE-8204 (a) Advanced Power Electronic and Drives
EE-8204 (b) Modeling and analysis of Electrical Machines
EE-8204 (c) Applied Instrumentation

Elective II
EE-8207 (a) Advanced Power System Protection
EE-8207 (b) Fast Transients in Power Systems

THIRD SEMESTER

S. No.	Subject Code	Subject Name	L-T-P	Contact hrs/week	Credits	Marks		
						Theory		Practical*
						Internal Assessment	University Exam	
1	EE-8301	Elective-III	4-0-0	4	4	50	50	----
2	EE-8303	Elective-IV	4-0-0	4	4	50	50	----
3	EE-8351	Preliminary Thesis	- - -	20	10	----	----	100

* Practical marks are for continuous and end semester evaluation

Total Marks: 300 **Total Credits: 18**

Elective III
EE-8301 (a) Power System Deregulation
EE-8301 (b) Power System Reliability

Elective IV
EE-8303 (a) HVDC Transmission
EE-8303 (b) Flexible AC transmission Systems (FACTS)

FOURTH SEMESTER

S. No.	Subject Code	Subject Name	L-T-P	Contact hrs/week	Credits	Practical Marks*	
						Internal Evaluation	External Evaluation
1	EE-8451	Thesis	- - -	25	15	100	100

* Practical marks are for continuous and end semester evaluation

Total marks: 200 **Credits = 15**

Note:

1. Duration of end semester examination in each theory and laboratory course is three hours.
2. The examination in the subject of thesis is to be conducted jointly by two examiners, one of which will be the thesis supervisor, and the other, an external examiner.

3. The requirement for the award of ME is successful completion of 12 theory courses, 2 practical courses and satisfactory completion of thesis.

Total M.E. Marks: 1650 **Total M.E. Credits: 75**

EE-8101
ADVANCED POWER SYSTEM ANALYSIS

L T P
4 0 0

External: 50
Sessional: 50
Credits: 4

Note: Examiner shall set eight questions covering entire syllabus. Candidate will be required to attempt any five questions.

Load Flow - Graph theory-primitive network and incidence matrix -Formation of various network matrices by singular transformation-Representation of regulating and off nominal ration transformers-Conditioning of Y Matrix – Load flow-Newton Raphson method-Decoupled – Fast decoupled Load flow --three-phase load flow**.**

DC power flow –DC Power flow-Single phase and three phase -AC-DC load flow - DC system model – Sequential Solution Techniques.

Fault Studies -Analysis of balanced and unbalanced three phase faults – fault calculations – Short circuit faults – open circuit faults.

System optimization–Economic Load dispatch strategies – effect of transmission losses - Sensitivity of the objective function- Formulation of optimal power flow-solution by Gradient method-Newton's method-Economic dispatch of power between the areas.

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

Recommended Books:-

1. Grainger, J.J. and Stevenson, W.D. "Power System Analysis", Tata McGraw hill, New Delhi, 2003.
2. Singh, L.P. "Advanced Power System Analysis and Dynamics" New Age Publications 2012.
3. Pai, M.A. "Computer Techniques in Power System Analysis", Tata McGraw hill, New Delhi, 2006.
4. Wood, A.J. and Wollenberg W.F. "Power Generation, Operation and Control", 2nd Edn, John Wiley & Sons, New York, 1996.
5. Stagg, G.W. and EI-AbaidA.H, "Computer methods in Power system analysis", McGraw Hill, New York
6. Sadat, H. "Power System Analysis", Tata McGraw hill, New Delhi, 2002.

EE-8102
POWER SYSTEM OPERATION AND CONTROL

External: 50 L T P
Sessional: 50 3 0 2
Credits: 3

Note: Examiner shall set eight questions covering entire syllabus. Candidate will be required to attempt any five questions.

Introduction:- System load variation: System load characteristics, load curves - daily, weekly and annual, load-duration curve, load factor, diversity factor. Reserve requirements: Installed reserves, spinning reserves, cold reserves, hot reserves. Overview of system operation: Load forecasting, techniques of forecasting, basics of power system operation and control.

Real Power - Frequency Control :-Fundamentals of speed governing mechanism and modelling: Speed-load characteristics – Load sharing between two synchronous machines in parallel; concept of control area, LFC control of a single-area system: Static and dynamic analysis of uncontrolled and controlled cases, Economic Dispatch Control. Multi-area systems: Two- area system modelling; static analysis, uncontrolled case; tie line with frequency bias control of two-area system derivation, state variable model.

Hydrothermal Scheduling Problem :-Hydrothermal scheduling problem: short term and long term-mathematical model, algorithm. Dynamic programming solution methodology for Hydro-thermal scheduling with pumped hydro plant: Optimization with pumped hydro plant-Scheduling of systems with pumped hydro plant during off-peak seasons: algorithm. Selection of initial feasible trajectory for pumped hydro plant- Pumped hydro plant as spinning reserve unit-generation of outage induced constraint-Pumped hydro plant as Load management plant.

Unit Commitment And Economic Dispatch :- Statement of Unit Commitment (UC) problem; constraints in UC: spinning reserve, thermal unit constraints, hydro constraints, fuel constraints and other constraints; UC solution methods: Priority-list methods, forward dynamic programming approach, numerical problems .Incremental cost curve, co-ordination equations without loss and with loss, solution by direct method and λ-iteration method. Base point and participation factors.-Economic dispatch controller added to LFC control.

Computer Control Of Power Systems :-Energy control centre: Functions – Monitoring, data acquisition and control. System hardware configuration – SCADA and EMS functions: Network topology determination, state estimation, security analysis and control. Various operating states, State transition diagram showing various state transitions and control strategies.

Recommended Books

1. O. I. Elgerd, „Electric Energy Systems Theory – An Introduction", Tata McGraw Hill Publishing Company Ltd, New Delhi, Second Edition, 2003.
2. D.P. Kothari and I.J. Nagrath, „Modern Power System Analysis", Third Edition, Tata McGraw Hill Publishing Company Limited, New Delhi, 2003.
3. L.L. Grigsby, „The Electric Power Engineering, Hand Book", CRC Press & IEEE Press, 2001.
4. Allen.J.Wood and Bruce F.Wollenberg, "Power Generation, Operation and Control", John Wiley & Sons, Inc., 2003.
5. P. Kundur, „Power System Stability & Control", McGraw Hill Publications, USA, 1994

EE-8102
POWER SYSTEM OPERATION AND CONTROL LAB

Marks: 50
Credits: 1

1. Economic Load Dispatch with thermal power plants.
2. Economic Load Dispatch with Hydro thermal power plants.
3. Simulation of Facts controllers
4. Simulation of single -area and Two -area Systems.
5. Load forecasting and unit commitment.

EE-8103
OPTIMIZATION TECHNIQUES

L T P
4 0 0

External: 50
Sessional: 50
Credits: 4

Note: Examiner shall set eight questions covering entire syllabus. Candidate will be required to attempt any five questions.

PART A

Linear programming. Post-optimality analysis: change in cost vector and requirement vector, addition of a constraint and a variable, linear programming with bounded variables. (Scope as in Chapter 11, sections 11.1-11.5, 11.7 of Reference 2) (7)

Transportation problem. Bounded variables transportation problem (Scope as in Chapter 11, section 11.7 of Reference 3) (3)

Convex Optimization. Convex functions and their properties, convex programming problems, optimality conditions. (Scope as in chapter 7, sections 7.1-7.5 of Reference 1) (9)

Quadratic programming. Wolfe's Method (Scope as in chapter 7, sections 7.6, 7.7 of Reference 1) (3)

PART B

Nonlinear programming. Feasible directions and linearizing cone, constraints qualification, lagrange multipliers,Farka'Lemma (statement only) ,Karush-Kuhn -Tucker Conditions, duality in nonlinear programming, special cases of Wolfe dual. (Scope as in Chapter 8, sections 8.1-8.7 of Reference 1) (9)

Unconstrained Optimization: Line search method, Steepest descent method, Newton's method, Conjugate gradient Method (Scope as in Chapter 9, sections 9.1-9.5, 9.7 of reference 1)

Generalized convex functions. Quasiconvex, quasiconcave, pseudoconvex, pseudoconcave, linear fractional programming (Scope as in Chapter 12, sections 12.1-12.5 of Reference 1) (7)

Recommended Books

1. Suresh Chandra, Jayadeva, AparnaMehra. Numerical optimization with applications, Narosa Publishing House, New Delhi, 2009.
2. G. Hadley. Linear programming, Narosa Publishing House, New Delhi, 2002.
3. K.G. Murty. Linear and Combinatorial programming, John Wiley, New York, 1976.
4. KantiSwarup, P.K. Gupta, Man Mohan. Operations Research, 12th Edition, Sultan Chand and Sons, New Delhi, 2004.
5. M.S. Bazaraa and C.M. Shetty. Nonlinear programming: Theory and Algorithms, John Wiley, 1979.

EE-8104
DIGITAL CONTROL SYSTEMS

External: 50 L T P
Sessional: 50 4 0 0
Credits: 4

Note: Examiner shall set eight questions covering entire syllabus. Candidate will be required to attempt any five questions.

1. **Introduction:**
   Digital control scheme-configuration, Advantages, uses, implementation problems, sampling process, Sample and hold circuit,zero-order hold, Basic discrete time signals, z-transform, relationship between s-plane and z-plane,z-transform methods, inverse z-transform methods, region of convergence initial and final value theorem.
2. **Pulse transfer function and steady state Errors:**
   Block diagram reduction method, pulse transfer function, Multi-loop and MIMO systems, signal flow graph, Mason's gain formula in discrete-time domain, steady state errors, time domain analysis of second order systems time responses.
3. **Stability Analysis:**
   Introduction, jury stability test, bilinear transformation, stability by pole locations, Introduction to root locus method, rules of construction of root loci, Introduction to frequency domain analysis, Bode plots, Nyquist plots.
4. **State Space Analysis:**
   Introduction, definitions, realization of pulse transfer functions Diagonalizations; linear transformation, eigen vector, cofactor method Discretization of continuous time system, similarity transformation, solution of discrete-time state equations.
5. **Feedback Controllers and Lyapunor Stability Analysis:**
   Controllability, Condition for state controllability, Observability, condition for observability, pole placement, determination of state feedback gain matrix, output, feedback-state observers, Reduced order observer design, Regulator Design, Lyapunor stability Analysis.
6. **Digital control system:**
   Digital temperature control system, Digital position control system, Stepping motor and their control.

Recommended Books

1. KUO, B.C., Digital Control Systems , Oxford Series
2. George V I and Kurian C.P., Digital Control Systems, Cengage Learning
3. Gopal M., Digital Control and State Variable Methods, McGraw Hill Education (India) Pvt. Ltd..
4. Ogata, K., Discrete Time Control Systems, Prentice Hall.
5. Shinners, S.M. Modern Control System Theory & Design, John Wiley & Sons.
6. Related IEEE/IEE Publication.

EE-8105
POWER QUALITY

L T P
4 0 0

External: 50
Sessional: 50
Credits: 4

Note: Examiner shall set eight questions covering entire syllabus. Candidate will be required to attempt any five questions.

Electric power quality phenomena- IEC and IEEE definitions – power quality disturbances-voltage fluctuations-transients-unbalance-waveform distortion-power frequency variationsVoltage variations, Voltage sags and short interruptions – flicker-longer duration variations – sources – range and impact on sensitive circuits-standards – solutions and mitigations – equipment and techniques.

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

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

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

Recommended Books:-

1 Heydt, G.T.Electric Power Quality, Stars in a Circle Publications, Indiana,2nd edition 1994.

2 Bollen, M.H.J., "Understanding Power Quality Problems: Voltage sags and interruptions," IEEE Press, New York, 2000.

3 Arrillaga, J, Watson, N.R., Chen, S., „Power System Quality Assessment, Wiley, New York, 2000.

EE-8201
POWER SYSTEMS DYNAMICS AND STABILITY

L T P
4 0 0

External: 50
Sessional: 50
Credits: 4

Note: Examiner shall set eight questions covering entire syllabus. Candidate will be required to attempt any five questions.

Power System Stability– Basic Concepts and definitions-classification of stability-rotor angle and voltage stability.

Transient Stability- Swing equation-equal area criterion-critical clearing time and angle-solution of swing equation-Numerical methods -Euler method-Runge-Kutte method-synchronous machine representation–classical model-load modelling concepts-modelling of excitation systems-modelling of prime movers-effect of excitation system and governors-Multimachine stability –extended equal area criterion-transient energy function approach.

Small Signal Stability – state space representation – eigen values- modal matrices-small signal stability of single machine infinite bus system –effect of field circuit dynamics-effect of excitation system-small signal stability of multimachine system.

Voltage stability – generation aspects - transmission system aspects – load aspects – PV curve – QV curve – analysis with static loads – Loadability limit - sensitivity analysis-continuation power flow analysis

Recommended Books:-

1. Kundur, P. "Power System Stability and Control", McGraw-Hill International Editions, 1994.
2. Padiyar.K.R. "Power System Dynamic"' BS Publications.
3. Anderson, P.M and Fouad, A.A "Power System Control and Stability" Wiley Interscience Publication, 2nd Edition.

EE-8202
EHV AC TRANSMISSION

L T P
4 0 0

External: 50
Sessional: 50
Credits: 4

Note: Examiner shall set eight questions covering entire syllabus. Candidate will be required to attempt any five questions.

Introduction
Role of EHV AC Transmission, standard transmission voltages, average value of line parameters, power handling capacity.Line parameters Properties of bundled conductors, resistance, induction and capacitance of bundled conductor lines, temperature rise of conductors and current carrying capacity.

Voltage gradients on conductors
Charge potential relations for multi-conductor lines, surface voltage gradient on conductors, distribution of voltage gradient on sub conductors of bundle.

Corona Effects
Corona loss, attenuation of traveling waves, audible noise, limits for audible noise, AN measurement and meters, Day night equivalent noise level, limits for radio interference fields, RI excitation function, measurements of RI, RIV, Excitation function.

Switching Over voltages
Origin of over voltages and their types, over voltages due to interruption of low inductive current and interruption of capacitive currents, Reduction of switching surges on EHV systems.

Power frequency over voltages
Problems at power frequency, no-load voltage conditions and charging current, voltage control using synchronous condensers, sub synchronous resonance in series-capacitor compensated lines, state reactive compensating schemes.

Operational aspects of Power flow
Line loadability, effects of over load, reactive power limitations and over voltage problem.

Recommended Books:-

1. Begamudre, “EHV AC Transmission engineering”, Wiley Easter Ltd. 2nd Ed.
2. Edison Electric Institute, “EHV transmission reference book”, GE Co.
3. EPRI, Palo Alto, “Transmission line reference book 345 KV”.
4. Rudenberg, “Transient performance of electric power systems” McGraw Hill.

EE-8203
ADVANCED NEURAL NETWORKS & FUZZY LOGICS

External: 50 L T P
Sessional: 50 3 0 2
Credits: 3

Note: Examiner shall set eight questions covering entire syllabus. Candidate will be required to attempt any five questions.

Fundamentals of Neural Networks

Classical AI and Neural Networks, characteristics of neural networks, Historical perspective, The biological inspiration, models of artificial neuron & activation functions, Artificial neural networks & architectures, , Learning, types of learning, Supervised, Unsupervised, Re-enforcement learning, Basic learning rules. (5 hours)

Supervised Learning

Learning and memory, Representation of perceptron, Linear separability, Perceptron Learning, Training of single layer and multi-layer, back propagation training algorithm, Applications of back propagation, Radial basis function neural networks, Basic learning laws in RBF nets, Universal function approximation. (10 hours)

Associative Memory Networks

Introduction, Associative memory, Hopfield networks, Content addressable memory, Bidirectional associative memories. (8 hours)

Unsupervised Learning Networks

Introduction, Competitive learning, SOFM algorithm, Applications, Learning Vector Quantization, Introduction to counter propagation networks, ART network- architecture, Architectures & algorithms of ART1 & ART2 networks, Application (10 hours)

Applications

Application of neural networks- such as pattern recognition, load forecasting, Optimization, Associative memories, speech and decision-making. (3 hours)

Fuzzy Logic

Basic concepts of Fuzzy Logic, Fuzzy vs Crisp set, Fuzzy uncertainty & Linguistic variables, membership functions, operations on fuzzy sets, fuzzy rules for approximate reasoning, variable inference techniques, defuzzification techniques, Applications of fuzzy logic, Fuzzy system design, Industrial applications.

ANFIS(Adaptive Neuro Fuzzy system): Introduction, architecture, neuro-fuzzy applications.

(7 hours)

Recommended Books:

1. Principles of Soft Computing S.N. Sivanandam and S.N. Deepa- Wiley India
2. Neural Networks-by Simon Haykin
3. Fuzzy logic with engineering application-by Ross J.T(Wiley)
4. Introduction to artificial neural systems-by J.M. Zurada.(Jaico Pub)
5. Fuzzy Neural Control-by Junhong NIE& Derek Linkers(PHI)
6. Related IEEE/IEE Publications.

EE-8203
ADVANCED NEURAL NETWORKS & FUZZY LOGICS LAB

Marks: 50
Credits: 1

1. Introduction to MATLAB Programming.
2. Simulink Modeling using PowerSIM.
3. Case studies using Neural Network/ Fuzzy Logic/GA/PSO toolboxes
4. Simulation of Power Electronics controllers.
5. Optimization studies using GAMS/EUROSTAG
6. Case Studies using power system software

EE-8204 (a)
ADVANCED POWER ELECTRONICS AND DRIVES

L T P
4 0 0

External: 50
Sessional: 50
Credits: 4

Note: Examiner shall set eight questions covering entire syllabus. Candidate will be required to attempt any five questions.

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

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.

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

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

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.

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

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

Recommended Books:-

1. 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.

EE-8204 (b)
MODELING AND ANALYSIS OF ELECTRICAL MACHINES

L T P
4 0 0

External: 50
Sessional: 50
Credits: 4

Note: Examiner shall set eight questions covering entire syllabus. Candidate will be required to attempt any five questions.

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

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.

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

Determination of Synchronous Machine Dynamic Equivalent Circuit Parameters, Analysis and dynamic modeling of two phase asymmetrical induction machine and single phase induction machine.

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 modelling and self controlled operation; Analysis of Switch Reluctance Motors.

Recommended Books

1. Charles Kingsley,Jr., A.E. Fitzgerald, Stephen D.Umans, „Electric Machinery, Tata Mcgraw Hill,6ht Edition, 2003.
2. R. Krishnan,Electric Motor & Drives: Modeling, Analysis and Control, Prentice Hall of India, 2001.
3. Miller, T.J.E,. „Brushless permanent magnet and reluctance motor drives, Clarendon

EE-8204 (c)
APPLIED INSTRUMENTATION

L T P
4 0 0

External: 50
Sessional: 50
Credits: 4

Note: Examiner shall set eight questions covering entire syllabus. Candidate will be required to attempt any five questions.

1. Transducers, Classification of Transducers, including analog and digital transducers, Selection ofTransducers Static and Dynamic response of transducer System.
2. Measurement of length & thickness, linear Displacement, Angular displacement, force, weight,torque, Moisture, Level, Flow, pH & Thermal Conductivity, Measurement of FrequencyProportional, Geigermuller& Scintillation Counters.
3. Telemetry: Basic Principles, Proximity & remote Action Telemetry systems, Multiplexing, TimeDivision and frequency division.
4. Various types of Display Device, Digital Voltmeters, Dual Slope DVMS, Digital encoders, Analogand Digital encoders, Analog and Digital Data Acquisition System, A/D Converter.
5. Fibre Optic Technology for data transmission, Supervisory Control and Data Acquisition Systems(SCADA), Q-meter.
6. Electrical noise in control signals, its remedial measures.

Recommended Books:-

1. W.D. Coopper& A.D. Helfrick, Electronic Instrumentation and Measurement Techniques, PHI.
2. B.C. Nakra and K.K. Choudhary, Instrumentation Measurement Analysis, Tata McGraw-Hill.
3. Instrument Transducers by Hermann, K.P. Neubert.
4. Electrical Transducers for Industrial Measurement by pH Mansfield.
5. Instrumentation systems by Mani Sharma, Rangan.
6. Principles & Methods of Telemetry by Borden &&Thagnel.
7. Telemetry Method by Foster.
8. Related IEEE/IEE Publications.

EE-8207 (a)
ADVANCED POWER SYSTEM PROTECTION

L T P
4 0 0

External:50
Sessional: 50
Credits: 4

Note: Examiner shall set eight questions covering entire syllabus. Candidate will be required to attempt any five questions.

Static Relays:-

Advantages of static relays-Basic construction of static relays-Level detectors-Replica impedanceMixing circuits-General equation for two input phase and amplitude comparators-Dualitybetween amplitude and phase comparators.

Amplitude Comparators

Circulating current type and opposed voltage type- rectifierbridge comparators, Direct and Instantaneous comparators.

Phase Comparators

Coincidence circuit type- block spike phase comparator, techniques to measure the period of coincidence-Integrating type-Rectifier and Vector product type- Phase comparators.

Static Over Current Relays

Instantaneous over-current relay-Time over-current relaysbasicprinciples –definite time and Inverse definite time over-current relays.

Static Differential Relays

Analysis of Static Differential Relays –Static Relay schemes –Duo bias transformer differentialprotection –Harmonic restraint relay.

Static Distance Relays

Static impedance-reactance–MHO and angle impedance relaysamplingcomparator –realization of reactance and MHO relay using sampling comparator.

Multi-Input Comparators

Conic section characteristics-Three input amplitude comparator, Hybrid comparator-switched distance schemes, Poly phase distance schemes, Phase fault scheme, Three phase scheme, Combined and ground fault scheme.

Power Swings

Effect of power swings on the performance of distance relays –Power swinganalysis-Principle of out of step tripping and blocking relays-effect of line and length and sourceimpedance on distance relays.

Microprocessor Based Protective Relays

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

Recommended Books:-

1. Badri Ram and D.N.Vishwakarma, "Power system protection and Switch gear", TMH publication New Delhi 1995.
2. T.S.MadhavaRao , "Static relays", TMH publication, second edition 1989.
3. BhaveshBhalja, R. P. Maheshearі, Nilesh G. Chothani, "Protection and Switchgear", Oxford University Press.
4. C. Christopoulos and A. Wright, "Electrical Power System Protection", Springer International.
5. Stanley Horowitz, "Protective Relaying for Power System II", John Wiley & sons, 2008.
6. A.R. van C. Warrington Protective Relays Their Theory and Practice: Volume Two, Springer Science & Business Media, April 1978.

EE-8207 (b)

FAST TRANSIENTS IN POWER SYSTEMS

L T P
4 0 0

External: 50
Sessional: 50
Credits: 4

Note: Examiner shall set eight questions covering entire syllabus. Candidate will be required to attempt any five questions.

Lightning Overvoltages
Mechanism and parameters of lightning flash, protective shadow, striking distance, electrogeometric model for lightning strike, Grounding for protection against lightning– Steady-state and dynamic tower-footing resistance, substation grounding Grid, Direct lightning strokes to overhead lines, without and with shield Wires.

Switching And Temporary Overvoltages
Switching transients – concept – phenomenon – system performance under switching surges, Temporary over voltages – load rejection – line faults – Ferro resonance, VFTO.

Travelling Waves On Transmission Line
Circuits and distributed constants, wave equation, reflection and refraction – behavior of travelling waves at the line terminations – Lattice Diagrams – attenuation and distortion – multi-conductor system and multi velocity waves.

Insulation Co-Ordination
Classification of over voltages and insulations for insulation co-ordination–Characteristics of protective devices, applications, location of arresters – insulation co-ordination in AIS and GIS.

Computation Of Power System Transients
Modeling of power apparatus for transient studies – principles of digital computation – transmission lines, cables, transformer and rotating machines – Electromagnetic Transient program – case studies: line with short and open end, line terminated with R, L, C, transformer, and typical power system case study: simulation of possible over voltages in a high voltage substation.

Recommended Books

1. PritindraChowdhari, “Electromagnetic transients in Power System”, John Wiley and Sons Inc., Second Edition, 2009.
2. Allan Greenwood, “Electrical Transients in Power System”, Wiley & Sons Inc. New York, 2012.
3. Klaus Ragaller, “Surges in High Voltage Networks”, Plenum Press, New York, 1980.
4. Rakosh Das Begamudre, “Extra High Voltage AC Transmission Engineering”, (Second edition) Newage International (P) Ltd., New Delhi, 2006.
5. Naidu M S and Kamaraju V, “High Voltage Engineering”, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004.

EE-8301 (a)
POWER SYSTEM DEREGULATION

L T P
4 0 0

External: 50
Sessional: 50
Credits: 4

Note: Examiner shall set eight questions covering entire syllabus. Candidate will be required to attempt any five questions.

INTRODUCTION

Introduction to Power System Deregulation, difference between vertically integrated and restructured power systems, advantages of competitive environment in power system, components of restructured power system

Role of ISO, ISO in Pool markets, ISO in Bilateral markets, Operational planning activities of a GENCO: Genco in Pool and Bilateral markets,

TRANSMISSION PRICING AND WHEELING

Power wheeling: Definition and scope, cost components of transmission system, MW-mile and MVA-mile methodologies, Market Power, Bidding and Auction Mechanisms, Market Models, Transmission Open Access, Transmission Pricing

TRANSMISSION CONGESTION MANAGEMENT

Transmission congestion problem, market power, Impact of Congestion and Congestion Management, congestion management methodologies, preventive and corrective congestion management approaches

AVAILABLE TRANSFER CAPABILITY

Introduction, definition, principles of ATC determination and factor affecting ATC, methods of static ATC determination. Non-market methods, Market based methods, Nodal pricing, Inter-zonal Intra-zonal congestion management, Price area congestion management, Capacity alleviation method

Recommended Books:-

1. Kankar Bhattacharya, Math H.J. Boller, JaapE.Daalder, 'Operation of Restructured Power System' Klumer Academic Publisher – 2001
2. Mohammad Shahidehpour, and Muwaffaqalomoush, - "Restructured electrical Power systems" Marcel Dekker, Inc. 2001
3. Loi Lei Lai; "Power system Restructuring and Deregulation", Jhon Wiley & Sons Ltd., England.

EE-8301 (b)
POWER SYSTEM RELIABILITY

L T P
4 0 0

External: 50
Sessional: 50
Credits: 4

Note: Examiner shall set eight questions covering entire syllabus. Candidate will be required to attempt any five questions.

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

Static Generating Capacity Reliability Evaluation
Capacity outage probability tables, loss of load probability method, Frequency andduration approach.

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

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

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

Recommended 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.

EE-8303 (a)
H.V.D.C. TRANSMISSION

L T P
4 0 0

External: 50
Sessional: 50
Credits: 4

Note: Examiner shall set eight questions covering entire syllabus. Candidate will be required to attempt any five questions.

1. **H.V.D.C. Power Flow** : Merits and Demerits of H.V.D.C. over EE.H.V.A.C., Types of H.V.D.C.links. Control of H.V.D.C. links, Analysis of 3-phase bridge converter with grid control overlapangle U<= 60˚and U >= 60˚Derivation of equivalent circuit of H.V.D.C. link. Basic means ofcontrol of HVDC link, CCA, CC & CEA, Control Characteristic, combined characteristics of aconverter.
2. Harmonics in H.V.D.C. operation, types of filters used for harmonic elimination.
3. Protection aspects of H.V.D.C. link.
4. Parallel operation of A.C. and D.C. systems.
5. Corona and R.I. Characteristics of H.V.D.C. link.
6. Stability aspects of synchronous and asynchronous link.

RecommendedBooks:

1. HVDC Power Transmission System, K.R, Padiyar, Wiley Eastern Ltd., 1990
2. EE.W. Kimbark, Direct Current Transmission Vol: 1 Wiley Interscience, 1971.
3. J. Arrillage, H.V.D.C Transmission, Peter Peregrines, 1983.
4. J. Arrillage HVDC et. Al, Computer Modelling of Electrical Power System. John Wiley 1993.
5. S. Rao, EHV-AC and transmission Engineering practice, Khanna publishers, 1990.
6. Related IEEE/IEE publications.

EE- 8303 (b)
FLEXIBLE AC TRANSMISSION SYSTEMS (FACTS)

L T P
4 0 0

External: 50
Sessional: 50
Credits: 4

Note: Examiner shall set eight questions covering entire syllabus. Candidate will be required to attempt any five questions.

Introduction
Reactive Power Control in Electric Transmission Systems, Loading Capability and Stability Considerations. Introduction to Facts, related concepts and system requirements.

Static Compensators and Regulators
Principles of operation, control schemes and characteristics of shunt compensators like SVC and STATCOM; Principles of operation, control schemes and characteristics of series compensators like GCSE, TSSC, TCSC and SSSC; Voltage and phase angle regulators like TCVR and TCPAR; Combined compensators like UPFC and IPFC.

Applications
Application considerations of FACT devices.

Recommended Books:-

1. Understanding FACTS: N.G Hingorani, J Gyugi (JEEE Press).
2. Flexible AC Transmission Systems (FACTS), Y.H.Song (JEEE Series).
3. Thyristor Based FACTS Controller for Electric Transmission Systems-R Mathur& P.K Verma, IEEE Press (Wiley)
4. Reactive Power Control in Power Systems TSE Miller