Curriculum structure
(To be effective from 2016-17) admission Batch
JIS College of Engineering
Department: Electrical Engineering
M. Tech.
Specialization: Electrical Devices & Power Systems

Curriculum for M.Tech (Electrical Devices & Power System)

(For the students who were admitted in Academic Session 2016-2017)

Sl.	Course Code	Course Title	L	T	P	C
1st Year 1st Semester						
1	EAM101	Advanced Engineering Mathematics	3	1		4
2	EDPM102	Advanced Control System	3	1		4
3	EDPM103	Electrical Machine Analysis	4			4
4	EDPM104	Elective I	4			4
5	EDPM105	Elective II	4			4
6	EDPM191	Laboratory I: Advanced Control System Laboratory			3	2
7	EDPM192	Laboratory II: Elective II Laboratory			3	2
8	EDPM193	Seminar I			3	2
1st Year 2nd Semester						
9	EDPM201	EHV (AC & DC) Power Transmission	3	1		4
10	EDPM202	Advanced Power System Dynamics	4			4
11	EDPM203	Advanced Power System Protection	3			4
12	EDPM204	Elective III	4			4
13	EDPM205	Elective IV	4			4
14	EDPM291	Laboratory III Power System Lab			3	2
15	EDPM292	Laboratory IV Power System Dynamics Lab			3	2
16	EDPM281	Seminar II			3	2
17	EDPM282	Comprehensive Viva-Voce				4
2nd Year 3rd Semester						
18	EMM301	Introduction to Management	4			4
19	EDPM301	Elective V	4			4
20	EDPM381	Dissertation (Part-I)			20	10
21	EDPM382	Pre-submission Defense of Dissertation				4
2nd Year 4th Semester						
22	EDPM481	Dissertation (Completion)			24	14
23	EDPM482	Post Submission Defense of Dissertation				8

EDPM104 Elective I

A. Signal Processing
B. Power System Planning & Reliability

EDPM105 Elective II

A. Power System Operation & Control
B. Power System Harmonics
C. Advance Power System Optimization

EDPM204 Elective II

A. Power Electronics
B. Soft Computing Techniques

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C. Facts Devices

EDPM205 Elective II

A. High Voltage DC Transmission System

EDPM301 Elective II

A. Generation of Non- Conventional Energy
B. Microprocessor & Microcontroller

COMMON DETAILED SYLLABUS

Advanced Engineering Mathematics

EAM-101
Contact: 3L+1T
Credit: 4

Complex Variables: Review of complex variables, Conformal mapping & transformations, Function of complex variables, Pole and singularity, Integration with respect to complex argument, Residues and basic theorems on residues.
Numerical Analysis: Introduction, Interpolation formulae, Difference equation, Roots of equations, Solution of simultaneous linear and non-linear equations, Solution techniques for ODE and PDE, Introduction to stability, Matrix eigen value and eigen vector problems. **Optimization Technique:** Calculus of several variables, Implicit function theorem, Nature of singular points, Necessary and sufficient conditions for optimization, Elements of calculus variation, Constrained Optimization, Lagrange multipliers, Gradient method, Dynamic programming.
Linear Algebra: Vector space, Linear dependence of vectors, basis, linear transformations, inner product space, rank and inverse of a matrix, solution of algebraic equations, consistency conditions, Eigen values and eigen vectors, Hermitian and Skew Hermitian matrices.

References:
1. John B. Conway, Functions of one complex variable, Springer International.
2. James Ward Brown & Ruel V. Churchill, Complex variable and application., Mc Graw Hill International edition .
3. John H. Mathews, Numerical Methods for Mathematics , science and Engineering, PHI

4. D.C. Sanyal and K. Das, A text Book of Numeriacl analysis, U.N. Dhar & Sons Pvt. Ltd.
5. S.S.Rao, Optimisation theory and application, Wiely Eastern limited
   Hoffman & Kunze. R, Linear Algebra, PHI.

Advanced Control Systems

EDPM-102
Contact: 3L+1T
Credit: 4

Review of Modeling and Analysis of LTI Systems: Modeling of physical Systems. Design specifications and performance indices, Motion control systems, Transportation lags. Approximation of time-delay functions., Sensitivity of control systems to parameter variations. Effects of disturbance of signals. Disturbance rejection.

Analysis in state-space: A perspective on state-space design. State variables. State models for physical systems. SISO and MIMO systems. Solution of state equations. Transfer function. Eigenvalues and eigenvectors. Jacobian linearization technique. State transformations and diagonalisation. Transformation to phase- variable canonical form. Controllability and observability. Duality property. Stability.

Introduction to Discrete-time Systems: Basic elements of discrete-time control system. Z-transform and properties. Inverse Z-transform. Difference equation and its solution by Z- transform method. Z-transfer function. State diagram of digital systems. Time delay. Direct, cascade and parallel decomposition of Z-transfer functions.

Feedback control design: Continuous control design. Proportional, derivative and integral control action. PID controller tuning rules. Ziegler-Nichols method. Two degree of freedom control systems. Compensator design using Bode diagram in frequency response approach. Lag, Lead, Lag-lead compensator. Control law design for full state feedback by pole placement. Full order observer system. Observer based state feedback. Separation principal.

Non linear system:

Classification and types of non-linearity. Phenomena peculiar to non-linear systems. Methods of analysis. Linearization based on Taylor's series expansion. Jacobian Linearization. Phase trajectory and its construction. Phase-plane analysis of linear and non-linear sustems. Existence of limit cycles. Describing function of typical non-linearities. Stability analysis by

DF method. Introduction to DIDF. Popov's circle criterion. Stability analysis by Lyapunov's indirect and direct methods, Lypunov's theorem.

References:

1. Ogata, K – Modern Control Engineering, PHI Learning
2. Kuo, B.C. – Automation Control Systems, Prentice Hall
3. Roy Choudhury, D – Modern Control Engineering, Prentice Hall
4. Nagrath, J. J. Gopal, M – Control System Engineering, New Age Pub.
5. Schulz, D.G. and Melsa, . L. – State Functions and Linear Control Systems, McGraw-Hill.
6. Stepheni, Shahian, Savant, Hostetler – Design of feedback control systems, Oxford University Press.
7. Vidyasagar- Nonlinear system analysis, Prentice-Hall.

Electrical Machine Analysis

EDPM 103

Contact: 4L Credit: 4

Matrix Analysis of Electrical machines and circuits. Power invariance transformations, Modeling & solutions. Generalized machine of first kind: quasi holonomic reference frame, impedance matrix, torque matrix, flux and current density matrices. Modeling DC machines: steady state and transient analysis, repulsion and universal machines, cross field generator. Matrix analysis of single and three phase transformer under steady state and transient conditions, rectiformer. General theory of electrical machines in rotational frame: generalized machine of second kind, holonomic and nonholonomic reference frame, torque matrix, voltage and impedance matrix. Analysis of single phase and three phase induction machines,analysis using revolving field theory, sequence reference frame state space modeling of electrical machines, equivalent circuits, synchronous generator under sudden short circuit, generalized fault analysis.

References:

1. Generalized theory of Electrical Machine, DP Sengupta

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Power System Planning & Reliability

EDPM 104(b)
Contact: 4L Credit: 4

Load Forecasting: Load Forecasting Categories-Long term, Medium term, short term, very short term, applications of Load Forecasting, Factors Affecting Load Patterns, Medium and long term load forecasting methods- end use models, econometric models, statistical model based learning. Short Term Load Forecasting (STLF): Applications of Load Forecasting, methods- similar day approach, regression methods, time series, ANN, Expert systems, Fuzzy logic based method, support vector machines ANN architecture for STLF, Seasonal ANN, Adaptive Weight, Multiple-Day Forecast, STLF Using MATLAB'S ANN Toolbox, Training and Test Data, Stopping Criteria for Training Process, sensitivity analysis.
Power System Reliability: Basic Notions of Power System Reliability- sub systems, reliability indices, outage classification, value of reliability tools, Concepts and methodologies, power system structure, Reliability based planning in power systems, Effect of failures on power system, Planning criteria, Risk analysis in power system planning, multi-state systems.
Basic Tools and Techniques: Random processes methods & Markov models, Computation of power system reliability measures by using Markov reward models, Evaluation of reliability indices, Universal Generating Function (UGF) Method, Monte Carlo simulation.
Reliability of Generation Systems: Capacity outage calculations, reliability indices using the loss of load probability method, unit commitment and operating constraints, optimal reserve management, single and multi-stage expansion.**Reliability Assessment for Elements of Transmission and Transformation Systems**: Reliability indices of substations based on the overload capability of the transformers, evaluation and analysis of substation configurations, Reliability analysis of protection systems for high voltage transmission lines.

References:

1. Markey operations in electric power systems Forecasting, Scheduling, and Risk Management,
   Shahidehpour M, Yamin H, Li z, John Willey & sons.
2. Reliability evaluation of power systems, Billinton R, Allan R (1996) Plenum Press New York.
3. Computational Methods in Power system Reliability, D. Elmakias, Springer-Verlag.

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Power System Operation & Control

EDPM 105 (a)

Contact: 4L Credit: 4

Optimal Generation Scheduling: Thermal System Dispatching with Network Losses Considered, The Lambda-Iteration Method, Gradient Methods of Economic Dispatch - Gradient Search, Newton's Method, Economic Dispatch with Piecewise Linear Cost Functions, Economic Dispatch Using Dynamic Programming, Base Point and Participation Factors, Economic Dispatch Versus Unit Commitment, Coordination Equations, Incremental Losses, and Penalty Factors, The ***B*** Matrix Loss Formula Exact Methods of Calculating Penalty Factors, Reference Bus Versus Load Center Penalty Factors Reference-Bus Penalty Factors Direct from the AC Power Flow

Optimal Power flow: Optimal var control problem, controllable variables- Transformer taps, Generator voltages, Switchable shunt capacitors and Reactors, Objective functions, network performance constraints, constraints on state variables, Mathematical formulation, Solution of the Optimal Power Flow- The Gradient Method, Newton's Method, Linear Sensitivity Analysis, Linear Programming Methods, Sensitivity Coefficients of an **AC** Network Model Linear Programming Method with Only Real Power Variables, Linear Programming with AC Power Flow Variables and Detailed Cost Functions, Security-Constrained Optimal Power Flow, Interior Point Algorithm, Bus Incremental Costs

Load Frequency Control: control area concept, Block diagram and LFC of an isolated power system, Governor droop characteristic, AGC, primary and secondary frequency control, LFC of inter-connected power systems, Modes of tie line operation-flat frequency, flat tie line, tie line with frequency bias, Area control error, State space representation of two area system

State Estimation: Types of estimators–static, dynamic, tracking estimators. Least Squares and Weighted Least squares estimation, formulation, solution techniques, Bad data identification and detection.

Security Analysis: Normal, Alert, emergency, Restoration states in a power system. Security analysis, Security assessment, Security monitoring and Security controls**.** Credible and incredible.ontingencies, Contingency identification and Contingency ranking, Security**.** Calculation procedures.

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Deregulation: What is deregulation? Background to deregulation and current situation, Benefits of a competitive electricity market.

***References*:**

1. Power generation, operation, and control, Allen J. Wood, Bruce F, Wollenberg.

Power System Dynamics

EDPM 202
Contact: 4L Credit: 4

Basic Concepts: Basic structure of the power system, Power System Control requirements, Power system and Associated Controls Classification of Power System Dynamics, rotor angle, frequency and voltage instability, Extended Equal Area criterion, types of rotor angle instability- small signal & large signal stability. short term, mid-term and long term instabilities.

Modeling: Synchronous Machine

Synchronous generator subjected to electromagnetic disturbance, reactances and time constants –
Steady state operation, transient operation, sub transient operation, generator and system reference frame, Power, Torque and swing equation, synchronous generator model types. Advanced machine modeling-flux linkage equations in stator reference frame, flux linkage equations in rotor reference frame, power equations, voltage equations.

Excitation System

Requirements, functions and elements of excitation system, Types and dynamic performance
measures Control & protective functions, basic components, UEL, OEL and Power system stabilizer, basic block diagram derivation and IEEE model types for stability studies, Excitation system response, open-loop and closed-loop response.

Turbines and Governing systems

Governor system basic building blocks, Hydraulic turbine-Governor-hydraulic system model, MHC and EHC Governors, **Load** Static and dynamic load models

Time domain Simulation

Review of modified Euler, R-K Gill and trapezoidal methods, PE and SI methods, Transient
stability
enhancement.

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Energy Function Methods
Physical & mathematical aspects, Lyapunov's method, Energy Function formulation, PEBS
method for estimating region of
attraction.

Small signal stability:
Fundamental concepts-stability of dynamic systems, Eigen properties of state matrix, SSS of SMIB classical model, effect of field circuit dynamics, effects of excitation system and PSS, SSS of multimachine and large systems.

Voltage Stability:
Voltage instability, Voltage collapse -phenomena, Transmission line characteristic, Factors influencing voltage stability, Voltage stability analysis methods.

References:

1. Power System Stability and Control, Prabha Kundur, McGraw- Hill 1994
Power System Dynamics and Stability, P.W. Saur & M.A. Pai, Prentice Hall 1998
2. Power System Dynamics Stability and Control, K.R.Padiyar, John Wiley & Sons 1996
3. Power System Oscillations, GJ Rogers, Kluwer Academic Publishers 1999
4. Power system Voltage stability, Carson W. Taylor, McGraw- Hill ,1994.

Power System Protection

EDPM 203

Contact: 4L Credit: 4

Introduction: Relay types & Fault detection principles, CT & PT specification, Sequence filters
Non-Pilot over current protection: principles, Time and/or current grading co-ordination, Directional over current relaying
Differential protection: principles, CT requirements
Non-Pilot Distance Protection: stepped distance protection principles, distance relay types & polar characteristics, phase relays and poly phase relays, distance relay performance and SIR, power swing blocking , distance schemes, under reach and over reach, protection of parallel and multiended feeders.
Pilot-Distance-protection: Communication channels, Tripping and blocking modes, directional comparison blocking and unblocking, under reaching transfer trip, PUR/POR transfer trip, phase comparison.
Single and three pole auto reclosing in HV and EHV transmission systems.
Bus protection: High & moderately high impedance relaying, CT
requirements

Unit Protection of Feeder: Feeder differential protection, including pilot wire, current differential and phase comparison schemes

Protection of transformers: including biased and high impedance differential schemes, CT connections, 2 & 3 point differential protection, earthing transformers

Protection of high voltage capacitor banks: including consideration of inrush currents, over current, over voltage, and differential protection schemes

Protection of large motors: including differential and earth fault protection, thermal overload considerations, starting and stalling currents and the effect of negative phase sequence currents **Protection of large generators:** including stator & rotor earth fault protection, biased differential, high impedance differential, negative sequence, under frequency, over/under excitation, reverse power and out of- step protections.

References:

1. Power System Relaying, Stanley H. Horowitz, Arun G. Phadke, John Wiley & Sons
2. Protective Relays Application & Guide, GEC measurements
3. Power system protection, PM Anderson, IEEE Press book

Power Electronics

EDPM 204(a)

Contact: 3L+1T
Credit: 4

Review: Principle of operation of IGBT, GTO, Thyristor family, Principle of operation of SCR , Characteristics, Construction, Rating, Turn on and turn off of a SCR, Phase controlled converters, performance analysis continuous and discontinuous mode of operation.

DC-DC converters: step down, step up, switching mode regulators, multi output boost converter, chopper circuit design, state space analysis of regulators.

Pulse-Width-Modulated Inverters: performance parameters, advanced modulation techniques, voltage control of three phase inverters, harmonic reduction, current source inverters, variable DC-link inverter, inverter circuit design.

Resonant Pulse Inverters: series-resonant inverter frequency response, parallel-resonant inverters, voltage control of resonant inverters, ZCS and ZVS resonant converters, resonant DC- link inverters.

Multilevel Inverters: multilevel concept, Types of multilevel inverters: diode clamped, flying capacitor, cascaded, applications, switching device currents, DC-link capacitor voltage balancing.

Isolated Switching DC Power Supplies: Comparison between linear & switching power supply, Specification of SMPS, Different topologies, Flyback, Forward, Push –Pull, Half and Full Bridge), Control requirements and techniques, Practical SMPS design considerations, Protection

Power Conditioners and Uninterruptible Power Supplies: Power line disturbances, Power Conditioners. UPS & other residential and industrial applications.

References:

1. Power Electronics Circuits, Devices, and Applications, MH Rashid, 3rd edition, Pearson Education.
2. Robbins, Undeland Mohanand, *Power Electronics*, John Willey & Son's.
3. Cyril W Lander, *Power Electronics*, Mchraw-Hill International Editions, 1993.
4. Philip T. Krein, *Power Electronics.* Oxford university press, 1997.
5. B. K. Bose, *Modern Power Electronics & AC Drives*, Prentice-Hall, 1986.
6. Singh, and Khanchandani*, Power Electronics*, India: Tata McGraw-Hill, 198l.

Soft Computing Techniques

EDPM 204(b)

Contact: 4L
Credit: 4

Module 1

Introduction to Soft Computing, components of soft computing, traditional computing and drawbacks, advantages of soft computing techniques.

Module 2

Introduction to fuzzy logic: definition, general idea and importance in practical life. Fuzzy set theory: concept of fuzzy set, membership functions, comparison of fuzzy set and classical set. Operations on fuzzy sets, properties of standard operations, T norm and S norm, Extension principle and application. Height of fuzzy set, core of fuzzy set, support of fuzzy set, normal fuzzy set, normalization of fuzzy set, level set, α cut and strong α cut of fuzzy set, concentration and dilation of fuzzy sets, fuzzy singleton, crossover points.

Fuzzy relation: fundamentals of fuzzy relations, operations on fuzzy relations, composition of fuzzy relations, fuzzy reasoning, fuzzy relation inferences, compositional rule of inference, fuzzification. Fuzzy methods in control theory: Introduction to fuzzy logic controller, types of fuzzy logic controllers, basic structure of fuzzy knowledge based controllers, defuzzification methods, applications of fuzzy logic control.

Module 3

Introduction to artificial neural networks, artificial neuron model, types of activation

functions.
Learning in neural networks, feed forward and feedback neural networks, backpropagation training algorithm, Hopfield network, Boltzman machine. Self organizing map, learning vector quantization algorithm.

Module 4

Basic concept of genetic algorithm, comparison of GA and traditional techniques, objective
function and fitness function, crossover, mutation, GA search, applications of
GA.

Reference Books:

1. Klir, G.J. & Yuan,B.- Fuzzy sets and Fuzzy logic, theory and applications, Prentice Hall of
India Private Limited.
2. M. Ganesh - Introduction to fuzzy sets and fuzzy logic, PHI.
3. N. P. Padhy – Artificial intelligence and intelligent systems, Oxford
4. Timothy J. Ross – Fuzzy logic with engineering applications, Wiley.
5. Nie and Linkens,- Fuzzy Neural Control-Principles, Algorithms and Application, PHI
6. J.S.R. Jang, C.T. Sun, E. Mizutani - Neuro-fuzzy and soft computing, PHI.
7. Kosco, B.-Neural Networks and Fuzzy System.PH
8. Haykin- Neural Network; A Comprehensive Foundation, PHI
9. Rajasekaran and Pai – Neural Networks , Fuzzy Logic and Genetic algorithms: Synthesis and
Application, PHI.
10. Goldberg- Genetic Algorithms, Pearson.

High Voltage DC Transmission

EDPM 205(a)

Credit: 4L

Credits: 04

INTRODUCTION: Introduction to AC and DC Transmission – application of DC Transmission
– description of DC transmission – DC system components and their functions – modern trends in DC Transmission

CONVERTER: Pulse Number – Converter configuration – analysis of Graetz circuit converter bridge characteristics – characteristics of 12 Pulse converter

HVDC CONTROLLERS: General principle of DC link control – converter control characteristics – system control hierarchy – firing angle control – current and extinction angle control – Dc link power control – high level controllers

FILTERS: Introduction to harmonics – generation of harmonics – design of AC filters – DC filters – carrier frequency and RI noise

PROTECTION: Basics of protection – DC reactors – voltage and current oscillations – circuit breakers – over voltage protection – switching surges – lightning surges – lightning arresters for DC systems

Reference Books:

1. Kimbark, "Direct Current Transmission – Vol. I", John Wiley and Sons Inc., New York,

1971.

Generation of Non-conventional Energy

EDPM 301(a)
Contact: 3L+1T
Credits: 04

Introduction to Solar and Wind Energy: Recent trends in energy consumption – World energy scenario – Energy sources and their availability – Conventional and renewable sources – Need to develop new energy technologies – Solar radiation and measurement – Solar cells and their characteristics – Influence of insulation and temperature – PV arrays – Electrical storage with batteries – Solar availability in India – Switching devices for solar energy conversion – Stand alone inverters – Charge controllers – Water pumping – Audio visual equipments, Street lighting, Analysis of PV systems.
Power Conditioning Converters: DC Power conditioning converters – Maximum Power point tracking algorithms – AC power conditioners – Line commutated inverters – synchronized operation with grid supply – Harmonic problem
Wind Energy Conversion System: Basic principle of wind energy conversion – nature of wind – Wind survey in India – Power in the wind – components of a wind energy conversion system – Performance of Induction Generators for WECS – Classification of WECS
Induction Generator: Self excited Induction Generator for isolated Power Generators – Theory of self e excitation – Capacitance requirements – Power conditioning schemes – Controllable DC Power from SEIGs
Optimization Technique: Wind / Solar PV integrated systems – selection of power conversion ratio – Optimization of system components – Storage.

References:

1. Rai G.D., “Non – Conventional Energy Sources”, Khanna Publishers, 1993.
2. Rai G.D., “Solar Energy Utilisation”, Khanna Publishers, 1993.
3. Daniel, Hunt V, “Wind Power – A Handbook of WECS”, Van Nostrend Co., New York, 1981.
4. Gary L. Johnson, “Wind Energy Systems”, Prentice Hall Inc., 1985.
5. Freris L. L., “Wind Energy Conversion”, Prentice Hall (UK) Ltd., 1990.

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Microprocessor & Microcontroller

EDPM 302(a)
Contact: 3L+1T
Credits: 04

Intel 8086: Architecture and organization, registers structure, memory addressing, minimum and maximum mode of operation, interrupt structure, hardware, and software interrupt vector table. **Instruction set of 8086:** Arithmetic and logical instruction, bit manipulation instruction, process control instruction, programming example, microprogramming.
Controllers: PPI 8255- mode zero, mode one, mode two, bsr, interrupt controller 8259, DMA
controller 8237.
CISC and RISC system: structure of a typical CISC microprocessor, Pentium process register structure, integer pipe lines, flags
Applications: Machine control- traffic light and washing machine controller.
Micro controller: Architectures and organization of 8031/8051, programming technique, interfacing and applications.

References:

1. Advanced Microprocessor (1st edition) , Y Rajasree, New age international
2. Microprocessor, microcomputer and their applications (3rd edition), AK Mukhopadya, Narosa Publishers.
3. Microprocessor based laboratory experiments and projects (2nd Edition), AK Mukhopadya, S. Ratan & Co.

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